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Enhancing China's High-Tech Industry Development Using Experience of 'Four Tigers'

92FE0871B Beijing KEYAN GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 4, Jul 92 pp 57-61

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[Excerpts] Abstract: This paper presents some thoughts about China's high-tech development through an analysis of the high-tech industrial strategy of the "Four Tigers."

I. Introduction

South Korea, Taiwan, Hong Kong and Singapore have very little land and a high population density; they lacked industrial resources and their technical base was weak. However, since the 1970's, they practiced "export oriented" economic strategy and greatly accelerated their progress toward industrialization. In a very short time, they miraculously achieved an economic jump and became the "four tigers" of Asia. Their achievements have received great attention in the world. In 1987 alone, the Singapore economy grew by 8.8 percent and the economic growth in Hong Kong, Taiwan, and South Korea reached 11 to 12 percent. In this paper, we analyze the high-tech industrial strategy of the "four tigers" from a macroscopic view and offer an analysis as a reference for China's development of high-tech industry.

II. Main Strategies of High-Tech Industrial Development of the "Four Tigers" in Asia

Looking back at the history of the last 20 years, we realize that the "four tigers" employed largely the same development strategy. Taking advantage of their cheap labor and industrial structural changes in the United States and Japan, they actively imported inexpensive raw material and advanced technology that can be transferred to develop a labor-intensive manufacturing and assembly industry. They moved their economy forward with exports and their governments invested heavily in education and in R&D. By elevating their technological level, they gradually moved from labor-intensive industry to technology-intensive industry and formed their own high-tech industry.

(1) Establish an Export-Oriented Industrial Development Strategy

After the 1970's, Taiwan and South Korea switched from their previous "import substitution" strategy to an "export oriented" strategy. They let their enterprises participate in international competition and through survival of the fittest elevated their industrial vitality. They also achieved a balance between revenue and expenditure, imported technology, earned foreign exchange, and strengthened their industry. Since the 1980's, the "four tigers" have had great success in practicing an export oriented strategy in their high-tech industrial development. [passage omitted]

The "four tigers" obtained great success in their export oriented strategy, but that was only one of the factors that contributed to their high-tech development. Although they established an industrial manufacturing base in the 1970's, they did not possess high-tech development ability; their high-tech came primarily from the United States and Japan.

(2) Narrowing the Gap by Importing Technology

At the beginning of the 1980's, the industrial structure of the "four tigers" started to shift from a labor-intensive toward a technology-intensive model. They accelerated their pace of technology import from the United States and Japan and developed their own high-tech industry. The specific forms of technology import included purchasing technology, attracting foreign capital, and reverse investment in foreign high-tech industry. The specific steps taken were the following: Singapore and Hong Kong created an environment conducive to investment and attracted foreign or international companies to invest and build plants. Taiwan and South Korea not only tried to attract foreign capital but also extensively imported advanced technology and made "reverse investments" to attract high technologies from their birthplaces. This practice was borrowed from Japan. It avoided the time- and effort-consuming R&D stage and turned the imported technology into their own technology after mastering and modifying the technology. This practice was a shortcut in reducing the gap between them and the developed nations. [passage omitted]

Along with rapid technology development, the developed nations not only erected trade barriers but also did everything possible to retain their advanced technology; as a result, the "four tigers" encountered increasingly greater difficulties in importing technology. In addition to direct purchase, they are also exploring other avenues for acquiring technology.

(3) Improving Investment Climate and Attracting Domestic and Foreign Capital

Industries are not formed from technology alone. High-tech industries especially cannot be formed without capital. One of the necessary conditions for a developing nation to develop its own industry is sufficient and sustained investment. First and foremost, there should be a sound investment environment. The "four tigers" have taken a series of steps in this area. They have not only improved their labor quality, transportation, government efficiency and social stability, but also leveled the ground for foreign companies in terms of financial systems and legal procedures. In addition, they also implemented many investment incentives to improve the investment climate and have attracted large amounts of domestic and foreign investments. [passage omitted]

(4) Building Science Parks To Promote the Development of High-Tech Industry

The "four tigers" emulated the United States and Japan in building science parks and formulated incentive policies to attract domestic and foreign high-tech talents. These steps played an important role in their development of high-tech industry. [passage omitted]

(5) Strengthening High-Tech R&D Ability and Personnel Training

Imported technology played a leading role and quickly reduced the gap behind developed nations. The most fundamental action, however, is still the strengthening of one's own R&D ability so that one does not have to rely on others. For this reason, the "four tigers" are paying more and more attention to investment in R&D and high-tech personnel training. [passage omitted]

(6) Enlarging Investments in Foreign Countries and Starting Multinational Companies

The world economic development has shown that multinational companies are becoming the main players that control the world trade. Although investing overseas and building multinational companies are the game of mainly developed nations, some developing nations and regions, especially the "four tigers," are also beginning to do so.

Since the 1980's, the "four tigers" have shared three obvious common trends in expanding their investment in other countries. First, they moved their labor-intensive and assembly businesses overseas, adjusted their industrial structure, and elevated their industries to a higher level. Second, they built plants in the United States and in Western Europe and sold their products where they produced them. The purpose was to avoid the trade barrier of developed nations. An example is South Korea's investment in European countries to make color televisions and videorecorders. Third, they invested in the United States and Western Europe and entered the world center of high technology. They extended their contacts to obtain information and technology, made use of the personnel resources of the developed nations and kept abreast with high-tech development in the world. To this end, Taiwan and South Korea invested in the information industry and biotechnology in the United States. Naturally, the large amount of cumulated capital and market capacity contributed to the ability of the "four tigers" to make substantial investments overseas. But the main reason is still the urgent need for industrial structural adjustment and for high-tech in order to break the stronghold in many areas by the developed nations. The "four tigers" are also killing several birds with one stone by making good use of the capital, talent resources, and sales network of the developed nations to break into the center of the high-tech world. [passage omitted]

It seems that making investments in foreign countries is one of the strategies of the "four tigers" in achieving high-tech industrialization. It is also a means to enter the high-tech core and a necessary step toward international companies.

(7) Market Strategy for Entering the Center of High Technology

The United States, Western Europe, and Japan are the centers of world high technology and also the largest markets for high technology; 80 percent of the production and sales of high technology are concentrated in these three regions. The common strategy of the "four tigers" in developing high-tech industry is to import technology, capital, and talent from the centers and return with their own high-tech products. They are also investing heavily in the centers in order to cultivate their own high-tech seeds.

Taiwan and South Korea have always used the United States as their main export partner for electronic products. They sold enormous amount of semiconducting and information products to the United States. [passage omitted] What they have done not only diversified the international market but also broke through trade protectionism. This practice also made good use of the brand name sales network and is an effective route for companies not yet established in their product quality. The quality of Taiwan's high-tech products is not among the top grades, but the price is right. As original equipment manufacturers (OEM), they maintain an edge in both quantity and quality in the high-tech world. In South Korea, almost all the electronics companies use foreign brand names when exporting their products, more than 75 percent of the products had half of their manufacturers exporting as OEM.

In summary, the "four tigers" employed market strategy and made use of the high-tech of advanced nations in developing their own high-tech products. They then export their products to developed nations under OEM and occupy the market with inexpensive, high quality products. This strategy played an important role in the rapid development of high technology for the "four tigers."

III. Inspiration for China's High-Tech Development

An overview of the whole process by which the "four tigers" achieved high-tech industrialization showed that they adopted an export-oriented strategy and, while the developed nations are making industrial structural adjustments, imported advanced equipment and technology and attained industrialization using foreign capital. Subsequently, they moved rapidly toward high-tech industry and brought their products to the high-tech world centered around the United States, Western Europe and Japan. They invested in, or even purchased, high-tech companies in the United States, Europe and Japan so that they can keep pace with the world's high technology. The experience of the "four tigers" may serve as lessons or reference for China's effort.

1. The starting point for technology import should be high and unplanned or repetitious import should be avoided at all cost. Particular caution should be exercised in watching out for stiff conditions when importing technology from Japan. With China's present situation, free import is not possible. When a certain technology or production line is imported, efforts must be made so that short-term benefits may be derived from the imported technology. Delays are the same as waste. The dissemination of imported technology should be given attention. The designated office should conduct follow-up so that imported technology may become our own technology and be quickly absorbed.

2. Qualified high-tech companies (such as the electronics street in Zhongguancun, Beijing) should be encouraged to join forces, leverage their strength, improve their R&D and production capability, and sell their products on the international market. Without forming groups, it is difficult to round up investments and carry out mass production. For example, Changjiang Dynamics in China is a business group centered around Wuhan Qiqiang Generator Plant and in which several hundred businesses participate. The group is already a reality and has put many of its products on the international market.

3. In the short term domestic consumption should be suppressed and purchasing power of groups should be strictly controlled. The interest rate should be raised suitably to facilitate the collection of capital. Borrowing money usually has more disadvantages than advantages; it is better to attract direct investments from foreign companies.

4. Qualified high-tech companies should be encouraged to cooperate with foreign counterparts in R&D. We should make use of China's advantage in people and break into the circle of R&D organizations abroad. This would not only provide high-tech information in the world but also provide opportunities for importing technology.

5. Traditional large enterprises and capable industries should be encouraged to invest in high-tech or start their own high-tech enterprises. China's traditional large enterprises are in a good position financially and have their own research institutes with a full complement of talents. As long as the leadership is not short-sighted and willing to make long-range plans, the large traditional industries are fully capable of making a major contribution in the high-tech field.

6. Large enterprises should be encouraged to invest in major foreign companies, or even purchase foreign high-tech enterprises, so that foreign capital and technologies can be introduced to China. Using the sales network of foreign companies, international Chinese companies can be formed. Such companies will be able to compete on the international market.

7. Very few of China's current high-tech products have made their names known on the international market. Exporting products under OEM should be considered in order to expand the international market. This mode of trade has been proven effective by the "four tigers."

8. With today's economic development in the world, no country can make all the components of a product entirely within the country. However, we should try to master the manufacturing technology of certain key components so that we do not have to rely on others.

9. In addition to training high-tech management personnel, the technical level of technicians in high-tech industries is also an important issue. The state should provide a supplement for training so that new high-tech enterprises can quickly be on the way.

Measures To Industrialize High-Tech Achievements Discussed

92FE0871E Tianjin KEXUE XUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE & MANAGEMENT OF S.T.] in Chinese Vol 13 No 7, Jul 92 pp 26-28

[Article by Tang Zijun [0781 1311 0193] of the Economics Department, Hunan College of Finance and Economics]

[Text] Abstract: High technology industrialization is not only an important step in national economic development and economic efficiency improvement, it is also key to the improvement of international economic competitiveness. As a potential productivity, how does high technology convert into actual productivity? How does one convert intellectual products into material products? The important issue is the industrialization of high technology. It is a complex systems engineering effort that involves many domains of the society, including strategic planning, economic operation mechanism, and management system. Therefore, high technology industrialization can be achieved only through deepened reform. The author submits that there are the following measures to industrialize high-tech results: establish high-tech stock enterprises and venture capital companies, build technology-business enterprise groups, perfect technology legislation, and create a brand-new operation mechanism.

The role of high technology is well known in economic development. Liberation and development of productivity with high technology is a prerequisite for realizing China's second step strategic goals.

The effect of high technology on the economy depends not only on the level of high-technology development, but also on the rate of conversion toward high-tech industry. The industrialization of high-tech results involves a number of societal issues, including strategic planning, economic operation mechanism, and management system. It not only involves the external environment, but also the internal conditions determined by the characteristics of the high-tech industry itself. Having completed the Sixth and Seventh 5-Year Plans, China has achieved considerable results in high-tech research but few of them have been used in industrialization. Although more than 20 new and high-technology development zones have been built in China and the beginning of a high-tech industrial system has taken form, high technology still plays a relatively minor role in China's economic development. The reason is not that China's high technology is backward; instead, it is because the large backlog of high-tech results has not been efficiently converted into productivity. So how can we convert high-tech results into high-tech industries and into actual productivity? The key is to deepen the reform and take some effective measures.

Strategy 1. Establish a Stock-Based Operation System for High-Tech Enterprises and Solve the High Input Problem

High-technology industries are characterized by their high level of technology content, high added value, high investment, high risk and knowledge-intensive nature. Because of these features, the investment is large and the benefits are high. To speed up the formation of high-tech industry, there must be long-term, low cost and unrestrictive capital and production elements. In the present situation of capital shortage, it takes more than just concentrated investment by the state. We must reform the current operating system of high-tech industries and establish a stock-based operating system.

With the stock system, idle capital in the society can be gathered for use. As of the end of 1991, the Chinese people had more than 800 billion yuan in savings deposits and 200 billion yuan in cash. If 1 percent of this money can be raised to develop high-tech industry, it would be equal to 20 percent of the total technology investment made by Japan in the 30 years after World War II. The high profit and good economic benefits of high-technology industries can easily attract investment of idle cash. In the form of stocks, the capital is for long-term use by the enterprises; unlike a bank loan, the stock investment is less restrictive. A stock system is therefore the main strategy for solving the large investment required in the industrialization process.

Strategy 2. Establish Venture Capital Companies and Eliminate the Worry of Risk

High-technology industries not only require large investments, the risks are also high. The high risks are the worry of high-tech investors. If the risk factors are not eliminated, the large investments needed by high-tech industry will be affected directly. Investment risks are one of the factors suppressing the formation of high-tech industry. The state should form venture capital companies to eliminate the worry of investment risks. The electronics industry center at Santa Clara south of San Francisco, known as the "Silicon Valley," is a high-tech zone formed in the 1950's. Its value of production accounts for 8 percent of the total value of production of the entire U.S. electronics industry. The formation of such a large-scale high-tech zone cannot be separated from the role of venture capitalists. Statistics showed that two-thirds of all U.S. venture capitalists have offices in Santa Clara. In China, venture capital is still a void. To accelerate the industrialization of high technology, we cannot do without venture capital companies.

Strategy 3. Establish a Complete Legislative System for S&T as a Legal Protection

As a special group in the economic arena, high-tech industry (e.g., computers, biotechnology, etc.) further advances new economic fields. Current civil laws and economic laws can no longer cover all aspects of the new field. Therefore, the formulation of technology laws, strengthen management and regulation, and a legal system for technology have been placed on the agenda. The management responsibility and system for high technology will be clearly defined through technology legislation. Through legislation, the government policy and strategy for promoting high technology will be carried out. The legislation will also create a legal basis for developing technology, for maintaining national sovereignty, resources, and interests regarding technology. China has done a great deal of work in technology legislation and issued a series of laws and regulations to protect intellectual properties, such as the "Patent Law" and the "Copyright Law." However, as a legal system, the technology legislation needs urgent improvement and perfection. Many countries with developed high technology have advanced their domestic high-tech industry through technology legislation. For example, the United States issued the "Technology Reform Act" in 1980 and the "Cooperative Research Act" in 1984. Since the 1980's, Japan has issued a series of technology regulations including the "law for promoting areas of concentrated advanced technology industry." These can serve as references in China's effort to perfect its technology legal system.

Strategy 4. Form Technology-Enterprise Cooperative Business Groups To Speed Up Industrialization

The basic mode of high-technology industry development in China should make use of the foundation and resources of the traditional industry, concentrate the location, develop the edge of the traditional industry, begin with some projects and gradually expand into high-tech industrial zones. To do so we must break down the barrier between systems and departments. We must build consortia and combine research, development, and production into one entity. Technology-enterprise coops are formed to meet the above needs. It is formed by combining research units, universities, and large or medium enterprises. The focus is on the combination of research and production and the goal is to produce new products and to develop new markets. The driving force is in the improvement of productivity and economic efficiency. The enterprise is most familiar with the conversion of research results into products and the competitiveness of a product on the international market; it can therefore provide the high research units with market information so that the possibility of application and the scope of application may be considered when the research plans are made. The combination of technology and enterprise can therefore shorten the distance between research and production and greatly accelerate the industrialization of high-tech results.

Strategy 5. Creating a Brand-New Operation Mechanism Is Key to the Success of High-Tech Industrialization

The current economic operation mechanism is no longer capable of adjusting to the more flexible high-tech industry. Therefore, the key to realizing and developing high-tech industry is in the creation of a brand-new operation mechanism. This operating mechanism includes the internal mechanism of the high-tech industry and external environmental mechanism.

The internal mechanism of the high-tech industry must treat the following three relationships. The first relationship is between the development of high technology and the reform of traditional industry. Traditional industry is the foundation and main body of the national economy. We should not only develop new technology based on the traditional industry, but also apply high technology to the reform of traditional industry in order to improve the economic efficiency of the traditional industry. The second relationship is between overall planning and priority breakthrough. In view of the financial resources available today, we should have overall planning but cannot afford to do everything; the priority should be based on the market share of products. The third relationship is between research and production. We should find an appropriate meeting point for research and production and increase the cooperation between them.

To create the external environmental mechanism of the high-technology industry is to deepen the reform in the economic system, the political system, and the technological system. Unified science and technology policy should be formulated, financial and tax support systems should be established, high-technology investment policy should be defined, administrative organizations for high-tech development should be established, management layers should be reduced, high-tech development plans should be formulated, personnel should be trained, and economic incentives such as tax breaks should be used to move high-tech industrialization forward.

Present Policy To Govern High, New-Tech Industrial Development Zones

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[Article by Shao Zhengqiang [6730 2973 1730]]

[Text]

I. Present State Basic Policy for High-Tech Industrial Development Zone

1. Regulations of Tax Policy

The income tax rate of a development zone enterprise shall be reduced to 15 percent effective the date such status is established. The income tax rate shall be reduced to 10 percent when the value of exported products reaches 70 percent of the total value of production of the year in question. Income tax of new enterprises in the development zone shall be exempted for the first 2 years after the beginning of operation. A newly established enterprise based on Chinese and foreign investment and scheduled to operate for 10 or more years may be exempted from income tax for the first 2 profit-making years. Development zone enterprises established with domestic investment and with an annual net income not exceeding 300,000 yuan from technology consultation, service, and training related to technology transfer shall be temporarily exempted from income tax for the above-mentioned amount. For the part of income above 300,000 yuan, income tax shall be levied according to the tax rate that applies. For all new and high-technology products involved in the planned development of the "Torch Plan" and those that conform to the exemption and reduction conditions for new products, the exempted and reduced tax on products and on value added shall be used specifically for technological development and be exempted from income tax. Taxes exempted or reduced from the enterprises in the development zone shall be used as a unified state sponsorship fund. Independent accounting will be practiced and a responsible department shall monitor the exclusive use of this fund for development of high technology and new products. Bonuses extracted from retained net income generated by technology transfer, consultation, service, and training, provided they did not exceed 15 percent, shall be exempted from the collection of bonus tax. Bonus taxes shall also be exempted from bonuses distributed to employees of new and high technology export enterprises using the state incentive fund if the bonus did not exceed 1.5 months of standard salary. New buildings constructed for technology development and production using funds raised by the enterprises themselves shall be exempted from construction tax or investment direction regulation tax. All loans to the enterprises in the zone shall be paid back after the income tax has been levied. Taxes paid by new and high-technology enterprises in the development zone above and beyond the 1990 level shall be returned to the development zone to be used for construction in the zone provided this does not affect the taxes to be paid to the central government and that it is approved by local people's government.

2. Loan Regulations

Banks should actively support new and high-tech enterprises and make every effort to provide the necessary capital for production development. A certain amount of long-term bonds shall be issued to raise money in society for supporting the new and high-tech industry. Relevant departments may establish venture capital funds in the development zone for the development of high-risk new products. More mature development zones may initiate venture capital companies.

3. Preferential Policies for Construction

Capital construction items including production and operation of new and high-tech industries shall be planned uniformly and be given priority for inclusion in the local fixed assets investment. With the approval of the local government, new and high-tech enterprises may be exempted from buying national priority construction bonds. Equipment and facilities used in high-tech development and production may be depreciated using the accelerated rate.

4. Preferential Policy for Import/Export Customs Tariff

Raw material and components imported by new and high-tech enterprises in the development zone for the purpose of producing export products may be exempted from import license. The customs department shall examine and release such items based on the export contract and document approved by the new and high-tech industrial development zone. Enterprises may set up bonded warehouses and bonded factories in the zone. The export products resulting from processing imported raw material and parts shall be exempted from import tax, tax for imported products, and tax on the added value of the products. The export products of the new and high-tech enterprises, with the exception of state-restricted export items, shall be exempted from export duties. Instruments and equipment for the development of new and high-tech enterprises shall be exempted from import duties upon presenting certificates approved by the examination and custom departments.

5. Delegation of Power in Import and Export Business

Technology import and export companies may be set up in the development zone to promote high-tech products on the international market. Successful new and high-tech enterprises may be given the right to handle foreign trade business operations. These enterprises, with approval from the relevant departments, may set up branch offices abroad for business expansion.

6. Regulations on Personnel Management Policy

Multiple travels abroad by business and technical personnel of new and high-tech enterprises shall be handled according to State Document No. (1990)9 of the State Council. When different regions and departments are making job assignments and recruiting employees, priority should be given to the needs of new and high-tech enterprises for recruiting college graduates, graduate students, and returning students and experts.

7. Regulations on Pricing Policy

Prices of new products developed by new and high-tech enterprises but under state control (including state-set and state-guided prices) may be set by the enterprise during the trial sale period. This does not include certain specific products whose price must be set by the department in charge of pricing. The enterprise shall also report the price to the department in charge of price setting and price control. Prices of new products not under the state control may be set by the enterprise itself.

8. Scope of New and High Technologies

Microelectronics and electronic information technology, space science and aerospace technology, opto-electronics and unification of optical, mechanical and electrical technology, life science and biotechnology, materials science and new material technology, energy science and new energy source and conservation technology, ecology and environmental protection technology, earth science and oceanology technology, basic matter science and radiation technology, medical science and biomedical engineering, and other new technologies applied to the traditional industrial base.

9. Qualification of New and High-Technology Enterprises

(1) Engaged in the research, development, production, and business of one or more of aforementioned new or high technology. Purely commercial business not included. (2) Practicing independent accounting, management, and responsible for its own profit or loss. (3) The person responsible for the enterprise should be a technical person familiar with the research, development, manufacture, and sale of the product and is a full time employee of the enterprise. (4) Technical staff with a college education should exceed 30 percent of the total number of employees of the enterprise. Technical personnel engaged in R&D of the new or high-tech products should exceed 10 percent of the staff. For labor-intensive enterprises engaged in manufacture and service of new or high-tech products, at least 20 percent of the staff should be technical staff with a college education. (5) Have at least 100,000 yuan of capital and business space and facility commensurate with the business. (6) At least 30 percent of the annual total income should be used in product research and development. (7) The total income usually consists of technical income, value of new and high-tech products, value of general technical products, and technology-related businesses. The combined income from technology and from new and high-tech products should be at least 50 percent of the annual total income of the enterprise. Income from technology refers to income generated from consulting, technology transfer, technical service, training, design and contracts, technology export, absorption of imported technology, and income from intermediate trial production. (8) The enterprise should have a clearly stated business code and a rigorous technology and financial management system. (9) The [intended] length of operation is at least 10 years.

10. Policy Regarding the Time Limit for New and High-Tech Products

The period is usually for 5 years but high-tech products with a longer period may be extended for another 1 to 7 years.

11. Criterion for Recognizing a Research Unit as a New or High-Technology Enterprise

Publicly owned research units in the development zone that practice economic independence and whose administrative business fees are waived by the state may be converted into new and high-technology enterprises with the approval of the development zone office if they meet the criteria for new and high technology.

12. Management Organizations in Development Zone and Regulations for Their Functions

The State Council authorized the State Science and Technology Commission to manage the development zones and to carry out the following functions. Based on the law of the state and pertinent regulations and policies, the State Science and Technology Commission shall research and formulate policies, regulations and rules for the operation of the development zones. The area and boundary of development zones shall be defined, generic regulations and special projects for the development zones shall be formulated and implemented. The State Science and Technology Commission should organize and carry out international cooperation and exchange in the development zones, promote the internationalization of new and high-technology industries. The management organization of most development zones consists of a development zone management office and a general development company under the leadership of a management committee. The management committee is a leadership group generally made up of responsible officials of the provincial and municipal governments and the science commission. Its main missions are to ensure the successful implementation of the state's policies regarding the development zones, to formulate and carry out various incentive policies and management regulations of the zones. It shall also formulate and organize the development plans and projects for the zones. The management office is a standing administrative unit of the leadership group and is responsible for the day-to-day operation of the development zone. The construction and development general company is an enterprise corporation under the leadership group. The responsibility of the general company is to use various economic means in the development of the high-tech zone, to provide paid services for the enterprises in the zone and to develop new and high-technology products.

13. Qualifications of a Development Zone

(1) The city in which the development zone is located should have a certain number of colleges, universities, and research institutes, and a certain capability for developing new or high-technology products. (2) The city in which the development zone is located should have a certain number of key enterprises of medium and large size, it should already have or is acquiring some key industries with high-tech products suitable for the international market. (3) The location should be easily accessible and has good communication facility. It should also have commercial and financial institutes to facilitate foreign investment and high-quality service personnel. (4) The site city should be in a good financial situation and can provide ample financial and material support for the development zone and the "Torch Plan" projects. (5) The provincial and municipal governments should pay attention to the development zone. A complete management system should be established and the system should be versatile, efficient and contain regional preferential policies. (6) The development zone should have a well-defined region and a development plan.

II. Analysis and Recommendation for New and High-Technology Development Zone Policies

1. Comparing China's Policies for New and High-Technology Industries With Those in Foreign Countries

Compared with its foreign counterparts, the Chinese policies for new and high technology are more specific, direct, and assist the high-tech industry in more ways than one. New and high-tech industrial policies in foreign countries are mostly indirect and of a guiding nature; very few have direct incentive provisions. In the United States, for example, the assistance is in the form of management and market information instead of concrete incentives. In Japan the government is almost not involved in the development of the industrial department; the government mainly points out the direction and accomplishes its goals by inducing the industry to act. The degree and scope of incentives toward high-tech industry in foreign countries are also relatively limited. In Japan the "science city" law only allows the reduction of the fixed asset tax when the financial conditions permit. An enterprise may deduct from its income tax 20 percent of the portion of R&D expenses that exceeded the highest R&D costs in previous years. In Western Europe most of the countries assist their high-tech industry with low-interest loans or interest-free loans. Specific policies of the various countries will not be listed here.

2. Comparison of China's Policy for New and High-Technology Development Zone and Other Relevant Policies

In terms of scope and magnitude, China's new and high-technology development zone policy has not exceeded its previous preference policies for enterprises started by research institutes and universities and for special economic zones and economic technology zones in the coastal area. In terms of tax policy, university enterprises are obviously treated more favorably than development zones; but the reverse is true where import policy is concerned. In terms of tax on personal award, universities are treated somewhat more favorably than development zones. With regard to incentive policies for new products and intermediate test products, the state regulation waives product tax and value-added tax for new products and waives income tax for the first 3 years for intermediate test products. For enterprises in the development zone, however, the new products must also be from "Torch Plan" projects in order to qualify for products tax and value-added tax, so the preference policy toward the development zone is more restrictive. To qualify for intermediate product tax preference, the unit must be a publicly owned independent research unit; since many of the enterprises in development zones are collectively or privately owned, most of them do not qualify. In terms of magnitude, the tax breaks enjoyed by special economic zones and by economic technology development zones are much greater than those for the new and high-technology development zones. The tax breaks for foreign investors are also obviously greater for the special economic zones than the high-tech development zones. The only area where the state regulation is less restrictive for the high-tech zone than the special economic zone is in export.

3. Recommendations for New and High-Technology Development Zone

Based on the above analysis and comparison, we make the following recommendations to the responsible department for the current policy toward new and high-tech zones. First, there should be more coordination between the state, local, and departmental policies; presently there still exist some discrepancies among them. For example, the state policy allows 2 years of income tax waiver for new and high-tech development zone enterprises commencing with the date the enterprise begins operation, and payback of loan is always done after tax. The municipal government of Tianjin, however, has its own policy of allowing 3 years of income tax waiver, followed by 3 more years of 50 percent reduction in income tax for enterprises in the Tianjin development zone and payback of loan is always done before tax. There is also discrepancy between policies of the state education committee regarding university enterprises and the No. 12 document of the State Council. These discrepancies have caused difficulties in implementation of the various policies. It appears that timely coordination between the responsible departments is very needed. Second, policies of the development zone should take into account the special nature of new and high-technology enterprises. The development zones are important bases for building high-tech industries. They are sources of new technology for conventional industries and windows on the world. They are also experimental zones for deepening reform. These special characteristics should be fully reflected in the policies, but the contents of many current policies are similar to China's policy for foreign investment. For example, these two policies are almost the same regarding simplified foreign travel procedures for business and sales personnel and for the export of products. No special incentive was given to the development zone enterprises for the high-efficiency, high-gain, and high-risk nature of their business. The focus of the policy is not clear. Third, the development zone policy should help expand the function of the development zone. The functions of the development zone are mainly to "incubate," coalesce, diffuse, and demonstrate. In the implementation of the current policy, most development zones have established business service centers to "incubate" new and high technology. These service centers are helpful in attracting personnel, financial, material, and information resources and to "incubate" and coalesce new and high technology. But at the same time, the diffusion and demonstration functions are not fully developed and the effects on enterprises outside the development zone not covered by the preference policy are still very small. This is an issue for further study and is also an issue that affects future progress of the development zone.

Results of Implementing Postdoctorate System Reviewed

92FE0871A Beijing KEYAN GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 4, Jul 92 pp 18-22

[Article by Zhuang Yi [8639 3015], Specialists Office, Ministry of Personnel and Li Lianwei [2621 5114 0251], Chinese Postdoctorate Science Foundation]

[Text] Abstract: This article gives a brief description of China's effort in attracting overseas doctoral students since the establishment of the postdoctoral workstation in 1987. Characteristics of China's postdoctoral system are summarized and analyzed. Recommendations are given for advancing the role of China's postdoctorate system in international exchange of personnel.

Since the beginning of China's policy of reform and opening up, the government has made a major effort to develop S&T and education and to promote international exchange of personnel. A large number of talented youth were selected and sent overseas to study. Most of the government-sponsored students going overseas (especially the students pursuing Ph.D. degrees) have a solid foundation in their own discipline. After a few years of training in course work and research, these students will acquire advanced S&T knowledge and become sought-after talents in China's S&T, education, and national economic development. A great deal of attention is given to the questions of how to effectively use these overseas students, how to attract them to come back after their study, and how to further promote international exchange of talents.

As the result of kind concern and policy making by Deng Xiaoping and leaders of the State Council, and based on the recommendation of Professor T. D. Lee, the State Council approved a proposal in July 1985 to conduct a trial implementation of a postdoctorate workstation and postdoctorate system in China. Experience of the last 6 years has shown that the postdoctorate system is an important measure in cultivating high level specialists. The system has created a better working and living environment for postdoctorate researchers. It has also played an active role in the selection and training of talented youth, in the promotion of technological development, in strengthening academic exchange, and in attracting overseas students to come back and work.

I. The Postdoctorate Workstation Is an Ideal Place for Overseas Ph.D.'s to Fully and Rapidly Develop Their Talents

China's postdoctorate system is based on foreign experience and particular situations in China. Postdoctorate workstations were established at selected universities and research institutes where the academic level is high, research and living conditions are better, and a number of government-sponsored key research projects and high-tech projects are underway. Talented youths with domestic or overseas Ph.D. degrees are recruited to work for a period of time in the postdoctorate workstation. The postdoc workstation is popular among returning Ph.D.'s because it provides them with a high-level research environment to conduct independent research in a competitive atmosphere. The workstation also changed the "assignment for life" situation and gives the returning Ph.D.'s a broader selection of work units.

According to our survey of 261 postdoctorates who entered the workstation early or had gone through the workstation, they have conducted or participated in 414 high key, high-tech research, or national natural science foundation projects, or highly explorative frontier research projects and achieved encouraging results. Among the 261 people, 19 were awarded national or provincial-level prizes, more than 10 patent disclosures were made, and 748 papers were published in top international and Chinese academic journals or presented at international conferences. Their research output was noticeably higher than similarly [qualified] people who did not go through the postdoctorate experience.

The work of returning Ph.D.'s at the various postdoctorate workstations has received a great deal of attention and praise from the host units. At the conclusion of their postdoctorate tenure, 60 percent of them chose to remain at the host unit by "mutual consent." Others entered universities and research institutes through a competitive process. A great majority of them were awarded associate professor or associate scientist positions and more than 20 were promoted to the rank of professor or scientist.

Some of the postdoctorate researchers have assumed leadership positions in departments, institutes and laboratories. Many experts believe that some of the postdoctorates will become or have already become leaders in their respective academic areas.

The postdoctorates came from different universities or research institutes and brought to the hosting units different academic viewpoints, working methods and research styles. Postdoctorates returning from overseas particularly have used their connections abroad in advancing the exchange between the host units and foreign research institutes and academic organizations. For example, the chemistry postdoc workstation at Xiamen University recruited 16 postdocs in the last few years, including 10 from overseas. They have not only assumed the duty of many research projects assigned by the state, but also brought in 30 projects from the Natural Science Foundation, the Education Foundation, and from cooperation with foreign organizations. The funding for the 30 projects amounted to 1 million yuan and 100,000 U.S. dollars. They also obtained equipment donations from abroad valued at more than 200,000 U.S. dollars and established several physical chemistry and analytical chemistry laboratories that are first rate in China.

The postdoc workstations have also helped postdocs to go abroad for academic exchange. To date about one-third of the postdocs have gone abroad to attend international conferences and to take part in short-term research collaboration.

As the postdoctorate system developed in China, a small number of foreign Ph.D.'s were accepted as postdoctorates in China since 1989. Today, a dozen Ph.D.'s from America, Germany, Japan, Australia and other countries are working at postdoctorate workstations at Beijing University, Qinghua University, Beijing Agricultural University, and Dalian Institute of Physical Chemistry of the Chinese Academy of Sciences. The foreign postdoctorates have further broadened international personnel and academic exchange and enhanced the reputation of the Chinese postdoctorate system, which helped to attract even more overseas Chinese students to return and work.

II. Characteristics of the Chinese Postdoctorate System

In establishing the Chinese postdoctorate system, we learned from the systems in foreign countries and paid particular attention to the actual situation in China. Special policies were made and the system evolved and developed. The Chinese system is characterized by the following main features:

(1) It is funded, organized, and implemented by the government.

The Chinese government put great emphasis on the postdoctorate system. From the beginning, the government set down clear definition and regulation regarding the fundamental goal, direction, and policy. A "national management and coordination committee for postdoctorate research workstation" was established to organize, lead, and coordinate the effort. The committee consisted of famous scientists and leadership comrades from the Ministry of Personnel, the State Science S&T Commission, the State Education Commission, the Chinese Academy of Sciences, and the Ministry of Finance. This management committee was placed in the office for experts in the Ministry of Personnel.

Based on the number of postdoctorates, the state allocates an operating fund. The allocation for 1991 was 9.8 million yuan based on the 15,000 yuan per person standard. This money is used for postdoctoral research and living expense supplement. The state also allocated a total of 30 million yuan (including $4 million) to establish a postdoctorate science foundation. The interest and other gains of the fund were used in the support of particularly promising postdocs. The awardees of the support have the right to use the money for different research purposes. The support may be used to buy equipment, material, or books. It may also be used to attend international conferences or short-term cooperation projects. Unused money may be carried from one station to another, or be brought to a new unit after the tenure of the postdoctorate period. Equipment bought with the support money may also be taken along if there is the need. Even though residential housing is in extreme shortage in China, the state has allocated 10 million yuan of capital construction fund to build a batch of postdoctorate apartments. More money is planned to build more new postdoctorate apartments.

(2) It is planned in a unified manner and developed step by step.

China is a developing nation with limited financial and material resources, therefore, the postdoctorate system was centrally planned based on the needs of China's S&T and education and taking into account academic discipline and regional development. The postdoctorate workstations were established according to a volunteer and optimizing principle at many meetings of high-level prestigious experts in China. A total of 278 postdoctorate workstations were established at 156 universities and research institutes. These stations were distributed in 29 large and medium cities in China and covered 42 major disciplines in science, engineering, agriculture, medicine, and law. These stations involved one-third of all Ph.D. granting institutes in China and one-fourth of Ph.D. granting units. The research and academic levels of these stations were among the leaders in China. The stations are also equipped with first-rate laboratories, most of them with state or provincial-level key laboratories. They assume a large number of state high priority projects and high-tech research projects. These stations are therefore ideal places for talented young Ph.D.'s to choose and to make use of their talents.

(3) A series of special policies were established; they not only suit the particular situation in China but are also exceptions to the regular practice.

In order to provide postdoctorates a better working and living environment, to promote personnel movement and fair competition, and to improve efficiency, the government has formulated nearly 30 policy papers, regulations, and management rules. The following are some examples.

The principle of "dual selection" is followed in processing applications for postdoctorate positions and in assigning jobs at the end of the postdoctorate period.

The regulation does not allow Ph.D.'s graduated from a unit to enter the postdoctorate workstation of the same discipline at the same unit. Second-term postdocs (a term is 2 years and the maximum length is two terms) must move to a different postdoctorate workstation.

The spouse and young children of postdocs may move with the postdocs and take temporary residence. A spouse's job will be arranged by the unit according to regulations for detailed personnel. The supply quota of the spouse and children are based on the standard of local personnel of similar rank. Children's education is also treated the same way as regular residents. After a postdoc is assigned a permanent job after the postdoctorate period, the spouse and children may take up residence at the job location.

While working at a postdoc workstation, seniority is accrued the same way as regular employees of the state and fringe benefits are equal to that of regular employees of the work unit. The wages of postdocs are slightly higher than the standard wage of similar non-postdoctorate workers and there is a 100 yuan per month living supplement. Housing is also covered in the regulation.

When postdocs have a record of outstanding performance and achievement, the host unit may evaluate their academic qualification, administrative ability, and research results and may, based on the relevant regulation, make an exception and classify them under advanced technical professional positions. After their postdoc tenure and job assignment, the accepting unit may refer to the job classification and personnel need and hire them as professional technical employees. These hirings are not under quota restriction of the unit.

To solve the problems in assigning jobs to postdocs completing their tenure, universities and institutes without work increase quota or having already used their quota are allowed to accept the assigned postdocs first and then request additional quota. If a university or institute is already filled up or overfilled, they may also accept a certain number of postdocs coming out of the pipeline. Units already under the system of total wage contract index may increase their index when they take on postdocs.

In formulating and implementing the postdoctorate system, the government treats domestic and foreign degrees exactly the same. The idea that returning Ph.D.'s are those who cannot make it on the outside and the attitude of valuing foreign degrees over their Chinese counterparts are both very wrong. Naturally, considering the special situations of overseas Ph.D.'s and in the spirit of attracting them to come back, the government has taken some special measures. For example, when overseas Ph.D.'s apply to come back as postdocs, they will be accepted even if the quota is already filled. Overseas doctoral students may also apply to work in units without a postdoc station but which are qualified to have a station. These practices have broadened the selection of regions, cities, units and specialties for returning Ph.D.'s.

(4) Fully develop the initiative of all involved.

Today, there is an extreme shortage of senior level specialists in the 30 to 40 age bracket in universities and research units. This is referred to as the "talent gap." For this reason, many departments and units give high hope to the postdoctorate system. The Chinese postdoctorate system is characterized by coordination, efficiency, flexibility, and serving the grassroots level. It has made the associated departments and host units very anxious to make the system a success. To carry out the regulation of the state, host units have been extremely supportive of the postdoctorate research, spouse and children settlement, and logistic assurance. With the support of superior departments and local governments, many host units have built or provided hundreds of housing units for postdocs. To solve the problem of operating fund shortage for the postdocs, most of the units have come up with a considerable amount of money from research projects, lateral topics fund, S&T development income, and president or director funds to support postdoctorate research. Data showed that postdoctorate research funds contributed through various channels have far exceeded the state investment.

Due to the good results of the initial postdoc workstations and the postdoctorate system, there have been numerous requests from departments, local governments, universities and research institutes to broaden the scope of the workstations and to increase the number of postdoc positions. Following the regulation, some units have begun to raise their own money to recruit some postdocs.

The Chinese Postdoctorate Science Foundation has received contributions of 3.51 million yuan, HK$500,000 and US$50,000 from 13 units including the Ministry of Metallurgical Industry, Ministry of Construction, Ministry of Posts and Telecommunications, Ministry of Aeronautics and Astronautics Industry, Ministry of Energy Resources, PLA General Logistics Department, CAS, International Trust and Investment Company, China National Tobacco Corporation, Huarun Group, Inc., China National Petroleum Corporation, Zhenhua 851 Biotechnology R&D Company, and others.

In summary, the Chinese postdoctorate system is a system with unique Chinese features. It has been understood by the technology, education and other sectors of society. It has also received society approval and support and has opened promising new prospects.

III. Increase the Role of China's Postdoctorate System in International Personnel Exchange

After 6 years of practice, China's postdoctorate system is gradually gaining maturity and perfection. Several hundred Ph.D.'s returning to China to enter the postdoctorate program have generated increasingly greater impact among Chinese students abroad. There have also been positive responses from academic organizations from other countries and from international groups.

When China began to have postdoctorate workstations and to implement a postdoctorate system, American scientists immediately commented that "China is beginning to compete strategically in the world." In October 1985 and June 1988, two science and technology staff visited the person in charge of China's national postdoctorate management committee to find out about the postdoctorate system. China expert O. Aulings [phonetic] of the United States studied China's postdoctorate system and believes that China's postdoctorate workstations are an important step in creating the environment for Chinese students to return and work.

When scientists, diplomats, and government officials from France, Japan, and England met their Chinese counterparts, they expressed admiration and envy for the government support of China's postdoctorate system and their willingness to have further exchange and cooperation.

In the current situation, we are preparing for more close collaboration with domestic and foreign organizations so that personnel recruiting and exchange may be improved. Active measures will be taken to make the postdoctorate workstations better and better.

1. As system reform deepens in China, the postdoctorate system will be continually adjusted, improved and perfected. Financial and material resources devoted to the postdoctorate system will be increased so that the workstations become more attractive and postdoctorates may work, live, and grow in a better environment. The scale and number of workstations will be gradually expanded. The number of postdocs recruited will be increased from 500 to 1,000 in 2 to 3 years.

2. Make a great effort to promote the system. Work with promotion organizations, universities, research institutes, and embassies and consulates to make the overseas students understand the implementation situation of the system and put their minds at ease. More effort must be spent in studying and solving the various problems of returning students, including students sponsored by their previous working units and the problem of "come and go freely."

3. Develop a friendly relationship with international organizations and foreign groups. Broadly promote international exchange and cooperation. Gradually increase the number of foreign postdocs, encourage postdocs to conduct international cooperative research

and exchange, and systematically send postdocs abroad for professional improvement and work.

We believe that as reform and openness deepens and with a cooperative effort, China's postdoctorate system is destined for further development and for greater contributions in promoting the training of young scientists and technical personnel and in promoting international personnel exchange.

Study on Measures To Promote Industry-Academy Cooperation

92FE0871F Wuchang KEJI JINBU YU DUICE [SCIENCE AND TECHNOLOGY PROGRESS] in Chinese Vol 9 No 4, Jul 92 pp 19-20

[Article by Yang Dongzhan [2799 2639 0594] of the Science and Technology Office, the State Education Committee]

[Text] Cooperation between universities and industry is a worldwide trend in higher education development. Such cooperation can lead to economic, technological, and societal development. Cooperation between academia and industry has shown such a great momentum that it is receiving increasing attention of governments around the world. Experience has shown that this cooperation is not only called for by industrial competition and development but is also indispensable for the reform and development of universities.

The competitive situation in technology and production has made industries more reliant on the universities. This reliance shows up mainly in two areas. One is the demand for universities to continuously produce new research results so that the industries may increase their technology reserve and overall technical level. The other area is the demand for the university graduates to have stronger theoretical and practical base and to meet industrial development needs on various levels. The universities, as part of society, shoulder the important responsibility of developing science and technology and social culture. In order to meet the social service responsibility of universities and to adjust to the requirement for industrial and social development, the universities must understand society and industry so that they can constantly improve their relationship with industry. This cooperation will let the universities play their full role in the relationship and thereby develop themselves. Under society-wide production the relationship between the various systems in the society is becoming increasingly intimate and the traditional boundaries between economics, technology, and education are breaking down. These changes have promoted the cooperation between academia and industry.

Academia-industry cooperation is required by industrial development and is the prime mover for industrial development. A review of the current status of world economic development shows that the economic strength depends largely on the role of technology progress in the economic growth of the various countries and on the efficiency for converting research results into production technology, including the conversion of imported technology into productivity. For this reason, every industrial group in the world views academia-industry cooperation as one of the major conditions for their own development and actively seeks different forms of cooperation. Government departments in particular have treated academia-industry cooperation as a high priority task. Various measures were taken and corresponding policies were formulated to coordinate and support such cooperation. Examples are the U.S. effort to "rebuild the cooperative relationship between academia, industry, and government" and the Japanese effort to establish a "committee for industry-university cooperation."

The relationship between the industry and the university is mutually beneficial and complementary; it provides both sides new vitality and vigor. Such cooperation brings the university a continuous development momentum and greatly increases the enthusiasm of the industry to supply the university with money, supplies, intermediate test base, and teaching practice facilities. The industry comes with money and equipment and the university comes with personnel and research results. This mutually beneficial relationship makes the two sides rely on each other more and more and spurs both sides to make greater achievement.

In order to move academia-industry cooperation forward, the author makes the following recommendations:

1. Make full use of the authority of the government and form a strong means for coordination and regulation.

After a survey of academia-industry practice in different countries, the author recommends establishing academia-industry cooperation leadership and operation organizations at the state, local and departmental levels. These organizations will guide and coordinate the academia-industry relationship. Considering the complexity of the cooperation, governments at various levels should rely heavily on the relevant economic planning committee, science committee, education committee, and departments in charge of industry and commerce, tax, and banks. A coordination committee should be formed to promote close cooperation and mutual support. By making connections, studying policies and regulations, and mutual visits, we should strive to create a favorable environment for academia-industry cooperation and provide more opportunities for cooperation.

2. Further deepen system reform and perfect the responsibility system to form an industrial momentum of technological improvement and to mobilize the universities.

The purpose of reform is mainly to combine technology and economics and to promote sound progress in academia-industry cooperation. The contract system will be perfected so that the industry sets expanded reproduction as the goal and the overall quality of the enterprise and the workers are improved. The enterprises will be made aware of the importance and urgency of academia-industry cooperation so that they spontaneously and consciously improve technology and cooperate with the university. Through research cooperation, promotion of results, technological improvement, and personnel training, the scope of cooperation will be expanded and the relationship will become closer. While closely coordinating the state economic plan and technology plan, the enterprises will actively communicate with the university, provide technical help, give full consideration of the capabilities of the university, and in a timely manner involve the university in their technology improvement process.

3. Further improve the policy and encourage academia and industry to cooperate.

Based on the policies already issued and considering the unique nature of academia-industry cooperation, practical policies should be formulated. The policies must be specific and concrete in the areas of tax, loan, benefits distribution, sharing of results and intellectual properties. The relationship between different policies should be adjusted so that the policies may work together. With regard to the issues of university participation in technological improvement and transfer of research results, the funding should be suitably biased. Items with academia-industry cooperation should receive preference so that industry has the incentive to cooperate with the university. In order to accelerate the conversion of research results into industrial output, a tax waiver should be given to products of intermediate testing, secondary development, and industrial experimentation. Under the guidance of the policies, make sure that the enterprises devote the depreciation fee, income tax break, 1 percent of the sales, and technology transfer and technical service income toward R&D so as to raise more money for academia-industry cooperation.

4. Strengthen internal management of the universities to create a small-scale internal environment for academia-industry cooperation.

Universities should pay particular attention to leadership work to enhance cooperation. Universities with heavy involvement in the cooperation should establish leadership and operation organizations so that coordination issues may be periodically discussed. The industrial liaison system should be tried in order to maintain constant contact, make timely assessment of industrial information, systematically place teachers into industry for research and problem solving. Based on the schedule of cooperation and specific curricular needs, universities should maintain some flexibility in personnel deployment so that the teachers have ample time to get deeply involved in industrial problem solving. For teachers engaged in academia-industry cooperation, their rank and benefits should be listed separately and treated with preference. The criteria for evaluation should be based on the effects on industry and the economic benefits.

5. Continue to build bases for research, teaching, and production.

Universities should train technical personnel for industry. The forms of training may be surrogate training, targeted admission, joint training, and worker training. The direction and content of personnel training should meet the industrial needs. A pre-employment system may be used to give graduates 1 to 2 years for in-depth familiarization with the industry. Academia-industry cooperation should benefit teaching by renewing the curriculum, reforming the education system and cultivating talents. Stable production exercise bases and teaching-production-research consortia could be established through a number of avenues, including cooperation agreements, cooperative education, jointly running a college or a specialty, and jointly running a research institute. For existing cooperative research institutes, the university should strengthen its management and make full use of its functions.

6. The author recommends that the state and the industrial management department selectively choose a few large or medium enterprises as academia-industrial cooperative test points so that experience may be gained and promoted in the whole country.

Because the policies are still incomplete, we recommend that a few enterprises which have good cooperation with universities be chosen as test points. Management departments of the industry and the university will be coordinated and the effort will be carried on the state level. Faced with actual problems and difficulties in academia-industry cooperation, we should gradually investigate the methods and approaches for solving these problems, seek the optimal mode of cooperation, and perfect the policies. By so doing, we hope to establish an approach with unique Chinese characteristics that can be promoted to the whole academia-industry cooperation effort in China.

Attracting Overseas Chinese Professionals Urged

92FE0871D Beijing ZHONGGUO KEJI LUNTAN [FORUM ON SCIENCE AND TECHNOLOGY IN CHINA] in Chinese No 4, Jul 92 pp 45-47

[Article by Cai Pingsan [5591 1627 0005]]

[Excerpt] [Passage omitted] Faced with severe international competition in personnel talent, some developing nations have worked long and hard to stabilize the personnel resources in their countries and to prevent the loss of personnel talent. Measures taken include necessary limitation for the outflow of technical personnel, particularly senior technical personnel. The measures, however, are basically reactive and ineffective.

II

As international exchange in the economic, technological, educational and cultural areas increased in recent years, more and more developing nations and regions are shifting their attention from alleviating the talent loss to taking effective measures to attract overseas people to come back. Their efforts have produced good results. The large number of people returning from overseas have not only alleviated the talent shortage problems at home but also brought back urgently needed technology. Experience shows that attracting overseas personnel to return and service the homeland is an effective and practical approach for developing nations and regions in the international competition for personnel talent.

1. One of the necessary conditions for solving the talent loss problem and for effectively utilizing returning talents is to further open the gate and to ensure that people overseas may come and go freely. Different countries have reduced or eliminated restrictions for emigrating overseas; for example, the Egyptian constitution stipulates that a citizen has the right to move overseas temporarily or permanently. Countries have also guaranteed that their citizens can come and go at will. The Indian government places no restrictions on when their citizens leave or return.

2. More vigorously pursue the improvement of domestic conditions in order to provide better living and working environment for returning personnel. This includes: (1) Provide high financial compensation and ensure appropriate work. The Indian government established a "scientific talent pool" to receive returning personnel. Based on their qualification and experience, these returning talents were given a high salary and positions in universities, enterprises, and other departments. They were also allowed to compete for jobs of their desire and remain in the talent pool until they have found a satisfactory job. To date, more than 10,000 engineers and scientists have found suitable jobs through the assistance of the talent pool. (2) Establish science cities and research parks to provide an attractive research and living environment. In 1980 Taiwan established its advanced technology center—the Hsinchu Science Park—and attracted more than 500 engineers returning from the United States alone. India invested US$120 million and 250 acres in Tamil to build a science city and to provide returning talents with a superior environment.

3. Implement special projects and attract overseas talents using different incentives. Since 1976 the Turkish government has invited overseas talents to return and work for short periods of time, with travel and living expenses paid by the government. To date, Turkey has had more than 300 overseas experts make more than 1,000 trips home. This practice has gained more and more recognition and emulation by other developing nations. In 1977, the United Nations Development Agency took the Turkish approach and, with cooperation of some developing nations, implemented "Tokotain Project." The main activity of this project was for experts and scholars living in developed nations to return to their homeland and work for 3 weeks to 3 months, with travel and living expenses paid by the United Nations Development Agency.

4. Formulate emigration laws and policies to go with domestic and international laws. Some countries, such as Egypt, also practiced dual citizenship so that their citizens may live in foreign countries while retaining their Egyptian citizenship. This practice on the one hand bestows their overseas citizens the protection of home country constitution and laws, and maintains a natural link between the homeland and people overseas, and on the other hand provides an avenue for citizens to return and serve the homeland.

III

As a developing country, China also faces severe international competition for talents. From a historical perspective China has already accumulated some experience in attracting talents from overseas. When the New China was first established, the party and the government paid great attention to recruiting overseas talents. Dedicated organizations were formed to recruit "students studying in capitalist countries" under a policy of general and yet prioritized recruitment. This effort received positive response from overseas and more than 2,500 patriotic experts and scholars overcame hardship and returned to China in the 1950's and 1960's alone. These experts included Qian Zuesen [6929 1331 2773], Li Siguang [2621 0934 0342], Hua Luogen [5478 5012 1649], and Tang Auqing [0781 1344 1987]. Several decades later, these people became the central force in their profession. After the Third Plenum of the 11th Party Central Committee, the party and the government made a series of policies based on the objective demand of economic development to improve the working and living conditions of experts returning to China. These efforts formed the foundation for future recruitment of overseas talents.

Today, many of the overseas Chinese and students are superior talents sorely needed in Chinese S&T and economic development. Statistics show that, in the United States alone, there are 100,000 Chinese experts, which account for 80 percent of the total number of Chinese in the United States [as published]. Among them, 30,000 are recognized as world class technical people, which account for more than one-fourth of the 120,000 world class experts in the United States. They represent an important force that the socialist modernization construction could and must rely on. Active and sustained recruitment of these experts should be one of the major tasks in the new age of reform, openness, and strengthening the work on intellectuals.

Today we should learn from the experience of other countries, deepen the reform, expand the openness, and improve the recruitment of overseas talents. We recommend the following actions:

(1) Establish a complete system as soon as possible. Identify a number of distinguished experts and scholars in science and technology and other arenas. Identify a number of promising young researchers in world leading

S&T fields. Based on the needs in China, begin a focused and prioritized effort to recruit these experts and young talents.

(2) Broaden the connection and actively recruit overseas talents to return and serve. Possibilities include returning to China permanently, short term cooperative research, part time appointment in China, and appointment to China's overseas organizations (except diplomatic units). We should also encourage overseas experts to start S&T enterprises and research institutes in China under the pertinent Chinese laws. Such enterprises may be started by private individuals or in cooperation with some Chinese unit. Overseas experts should also be encouraged to invest in new and high-technology enterprises in China with their patented technology. When it is not possible for some to return and work, we should start cooperative research, technical consulting, technology trading and technical data and literature collection.

(3) Thoroughly implement the policy of coming and going freely. For overseas experts, we may use a service contract system. At the end of the contract, the expert's preference regarding staying or leaving will be respected.

(4) Take practical measures to provide overseas talents with the necessary living and working environment when they return to work.

(5) Initiate a survey of the achievement, specialty, and intention of overseas experts. Establish files on overseas experts, compile a who's who and provide information to recruiting units.

(6) Elevate the role of overseas Chinese organizations and returning experts and provide them with the necessary support so that they may become important links between China and overseas talents.

(7) Recruit overseas talents with more incentives and the advantages of new and high-technology development zones, national key laboratories, and openness regions near the coasts.

Study of Lightweight Mirror for Space Detail Reconnaissance Camera

93FE0048B Beijing ZHONGGUO KONGJIAN KEXUE JISHU [CHINESE SPACE SCIENCE AND TECHNOLOGY] in Chinese Vol 12 No 4, Aug 92 pp 33-38

[Article by Fu Danying [0265 0030 7751], deputy director of research, Beijing Space Electromechanical Institute: "Study of Lightweight Mirror for Space Detail Reconnaissance Camera"; MS received 25 Feb 92]

[Text] **Abstract**

Finite-element mathematical models are used to study various lightweight designs of scanning mirror for space reconnaissance camera. Stiffness analysis under the load condition of the mirror's own weight is carried out to obtain the distribution and variation of the displacement field. Finally, an optimum design which gives the lightest structural weight and satisfies the mechanical and optical performance requirements as well as the manufacturing requirements is presented.

1. Introduction

A scanning mirror used on spaceborne camera is typically made of low coefficient-of-expansion, high-specific-stiffness glass materials such as microcrystal glass (ceramic glass), molten silicon glass, etc. Since the mirror of a long-focal-length camera is bulky and heavy, it suffers large deformation under gravity and acceleration. However, the optical system requires that the maximum deflection of the mirror be less than $\lambda/20$ (λ is the wavelength). Generally speaking, the deformation of the mirror surface under its own weight can be calculated from the following empirical formula:

$$\delta = K \cdot \frac{d}{E}\left(\frac{D^2}{h}\right)^2 \qquad (1)$$

where K is a proportionality constant which depends on the shape of the mirror surface and the method of constraint, d is the specific gravity of the mirror blank, E is the modulus of elasticity, D is the aperture diameter, and h is the thickness of the mirror.

Equation (1) shows that for a given set of mirror conditions, the deformation is proportional to the 4th power of the diameter, and inversely proportional to the square of the thickness. However, increasing the thickness will necessarily increase the weight of not only the mirror but also of its support structures. In the case of a scanning mirror, a large moment of inertia will also cause problems in maintaining dynamic stability of the satellite attitude and increase power consumption.

In order to reduce the weight of the mirror and to limit its deformation under different mechanical and thermal conditions, various lightweight structural designs such as punched holes, grooves and drilled holes have been used. The U.S. earth resource satellite uses a closed-end honeycomb-plate design which not only increases the strength and stiffness, but also reduces the weight by 60 percent. The Shanghai Institute of Technical Physics has designed a lightweight mirror with hexagonal honeycomb-shaped holes for the FY-2 satellite and achieved approximately 50 percent weight reduction. While honeycomb-hole designs are effective in reducing weight, they are difficult to process because complicated ultrasonic micro-cutting techniques are required. In this paper, a simpler lightweight design which uses side-drilled longitudinal holes is proposed; the mirror is made of microcrystal glass because of its low coefficient of expansion, large modulus of elasticity and good polishing properties.

2. Description of the Mirror Structure

The configuration of the mirror surface is shown in Figure 1 and Figure 2. It is 95 mm thick and has a near-octagonal shape; the two far sides of the mirror are circular arcs each with a radius of 242.5 mm. The projection of a circular light field along the 45°-line of the mirror is an ellipse (indicated by curve A). At both ends of the mirror along the major axis of the ellipse, inclined surfaces are cut to reduce the weight and to increase the stiffness of the two ends.

3. Analysis Model

A finite-element mathematical model is generated by discretizing the original mirror structure; this model is used in the MSC/PAC2 structural analysis software on a COMPAQ 386 microcomputer to study the effect of varying mirror thickness. The results show that mirror deflection increases as its thickness is reduced, which is in agreement with equation (1). For given material and geometric shape, it is necessary to punch holes in the mirror to reduce surface deflection.

The symmetric part of the mirror structure is divided into either 8-node elements or 6-node elements (depending on the complexity of the structure). The cylindrical surface of the hole is simulated by an inscribed octagon, which yields a smaller hole than a circumscribed octagon; however, calculated results show that the difference is insignificant.

The nodes on the end surface perpendicular to the x-axis are completely constrained because the structure is attached to the flange. Also, anti-symmetry constraints are applied to the symmetric cross sections of the model to conform with reality.

4. Weight Reduction Analysis

4.1 Determination of the Mirror-End Bevel Angle Width Δx

As shown in Figure 1, since the mirror must contain the entire range of projection of the light field (ellipse A), Δx can be as large as 77.5 mm. Deflection calculations for

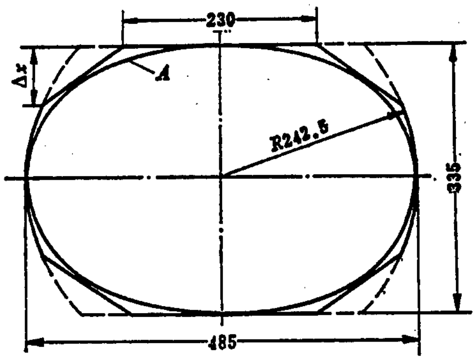

Figure 1. Plane View of the Mirror

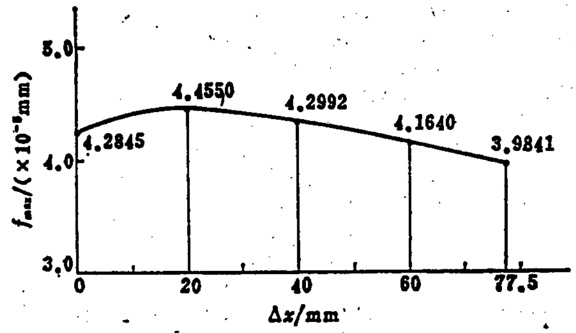

Figure 3. Effect of Δx on Mirror Deflection

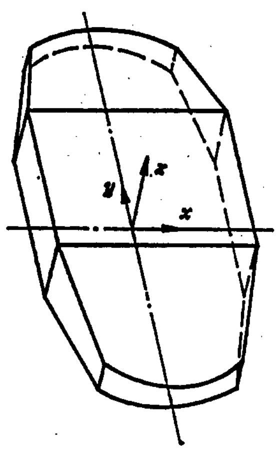

Figure 2. Configuration of the Mirror and Coordinate System

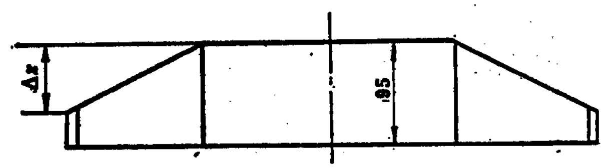

Figure 4. Side View of the Mirror

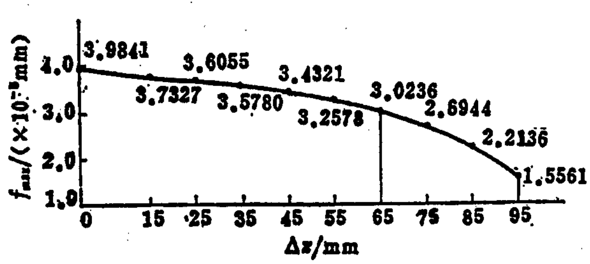

Figure 5. Effect of Δz on Mirror Deflection

five different values of Δx: 0, 20, 40, 60, and 77.5 mm (Figure 3) show that the maximum deflection reaches a peak value at Δx = 20 mm; it decreases with increasing Δx until a minimum value is reached at Δx = 77.5 mm. This demonstrates the necessity of cutting the opposite sides to achieve weight reduction.

4.2 Determination of the Mirror-End Back Bevel Angle Height Δz

Figure 5 shows the calculated results for the model Δx = 77.5 mm and for 10 values of Δz: 0, 15, 25, 35, 45, 55, 65, 75, 85, and 95 mm. The maximum deflection is seen to decrease with increasing Δz until a minimum value is reached at Δz = 95 mm, where the inclined surface intersects the end-points of the major axis. However, this Δz value is too large to be feasible from the point of view of manufacturing, operation and maintenance. A compromise value chosen for Δz is 65 mm, which corresponds to a value of f_{max} of 3.0236 x 10^{-5} mm.

4.3 Determination of the Diameter and Distribution of Weight-Reduction Holes

First, we select the following parameters: Δx = 20 mm, Δz = 0 mm, hole diameter = 65 mm, and hole axis located at z = 62.5 mm. Calculations are carried out for the following configurations with parallel holes drilled along the y-axis (symmetric with respect to the yoz plane): 1) four holes separated by 20 mm; 2) only two inside holes; 3) only two outside holes. The results are presented in Table 1.

Table 1. Mirror Deflection for Different Hole Configurations

Hole configuration	Four holes	Two inside holes	Two outside holes	No holes
f_{max} (x 10^{-5} mm)	3.8139	3.5845	5.1597	4.4550

Table 1 shows that the first two configurations yield smaller deflections than the no-hole configuration (see Figure 3). Also, the four-hole configuration is preferred because it provides additional weight reduction even though the deflection is slightly larger than that of the second configuration.

Next, we select the parameters: $\Delta z = 65$ mm, $\Delta x = 77.5$ mm, and consider four configurations with 30 mm rib reinforcements. To minimize computation time and storage space, the complex structure is approximated by a finite-element model symmetric relative to the coordinate system shown in Figure 2. Also, to study the effect of different hole size, the diameters of the two outside holes are reduced to 40 mm, and their positions are moved inward until the minimum separation is 20 mm. The calculated results for the four configurations are presented in Table 2 ($\Delta x = 77.5$ mm, $\Delta z = 65$ mm, $\varphi_{inner} = 65$ mm, $\varphi_{outer} = 40$ mm).

Table 2. Configurations With 30 mm Rib Reinforcements

Configuration	Four holes with rib reinforcement	Four straight holes	Inner holes with rib reinforcement	Outer holes with rib reinforcement
f_{max} (x 10^{-5} mm)	4.2342	4.2592	4.2415	4.2520

The values of f_{max} for these four configurations are all of the order of 4.25 x 10^{-5} mm, which shows that decreasing the hole size results in lower stiffness. However, optimization of the hole diameter has not been performed; the final hole diameter is chosen to be 65 mm because further increase in hole size will make manufacturing and assembly more difficult.

Next, we consider the four configurations where all four holes are 65 mm in size and have 30 mm rib reinforcements; the results are presented in Table 3 ($\Delta x = 77.5$ mm, $\Delta z = 65$ mm, $\varphi = 65$ mm).

Table 3. Four-Hole Configurations With 30 mm Rib Reinforcements

Configuration	Four holes with rib reinforcement	Inner holes with rib reinforcement	Outer holes with rib reinforcement	Four straight holes
f_{max} (x 10^{-5} mm)	2.6980	2.7503	2.7571	2.8238

It is seen that the four-hole configuration with 30 mm rib reinforcement meets the optical requirement of $\lambda/20 = 2.75 \times 10^{-5}$ mm.

4.4 Effect of Rib Thickness on Structural Stiffness (All Four Holes Are φ 65 mm)

(1) Four holes with equal rib thickness

By varying the rib thickness (because of symmetry, the actual value used is the half thickness Δy), the corresponding maximum mirror deflections have been calculated, as shown in Figure 6. When $\Delta y = 135$ mm, $f_{max} = 1.54 \times 10^{-5}$ mm; values of Δy greater than 135 mm are not considered because the effect on weight reduction becomes insignificant.

(2) Inner and outer holes with unequal rib thickness

First, a deflection curve is generated by fixing the outer rib thickness $\Delta y_1 = 135$ mm and varying the inner rib thickness Δy_2, as shown in Figure 7; then a second curve is generated by fixing the value of Δy_2 and varying Δy_1, as shown in Figure 8.

Figure 7 shows that when $\Delta y_1 = 135$ mm, the removed mass corresponding to $\Delta y_2 > 60$ mm has a significant

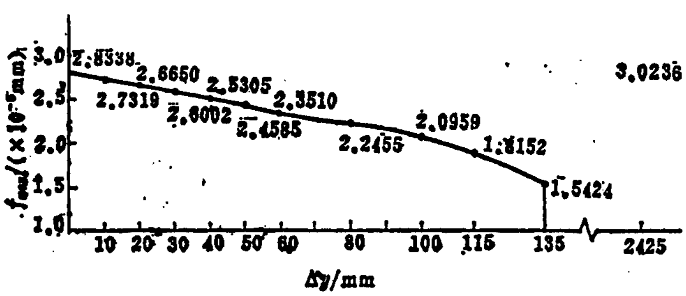

Figure 6. Effect of Rib Thickness Δy

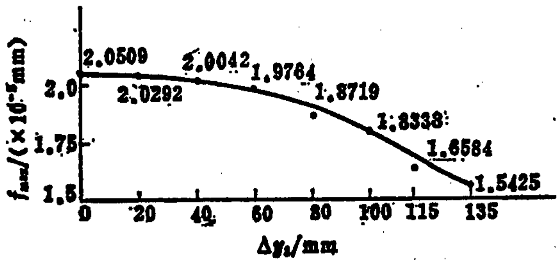

Figure 7. Effect of Δy_2 on Deflection, With Δy_1 = 135 mm

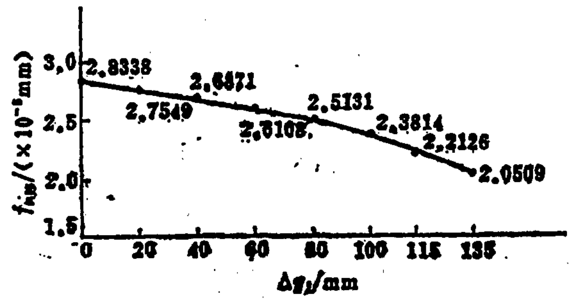

Figure 8. Effect of Δy_1 on Deflection, With Δy_2 = 0

effect on stiffness; on the other hand, Figure 8 shows that when $\Delta y_2 = 0$ mm, variation in Δy_1 has a uniform effect on stiffness.

5. Conclusions

The structure of the mirror and the constraint conditions are such that the mirror behaves like a two-way cantilever beam in the y direction and like a beam supported at both ends in the x direction. For such a structure, the contribution to the overall stiffness from one part differs considerably from another part; hence it is an extremely tedious procedure to obtain an optimum solution of stiffness under given geometric constraints.

Generally speaking, the outer mass has little or negative contribution to stiffness in the y direction; in the x direction, the contribution of the outer mass is large, whereas the contribution of the inner mass is small.

Since the optimum stiffness solution (for given constraint and load conditions and given geometry) in general is not the same as the minimum-weight solution, the solution of practical engineering value is the minimum-weight solution which satisfies the optical, mechanical, manufacturing, assembly and maintenance requirements.

Figure 9 [not reproduced] shows the minimum-weight solution for the structure described in this paper; the weight reduction (compared to the original structure at $\Delta x = 77.5$ mm, $\Delta z = 65$ mm) is approximately 44 percent. Of course, the maximum deflection, $f_{max} = 2.8338 \times 10^{-5}$ mm, is slightly larger than $\lambda/20$, but its good manufacturability makes it an acceptable design from the overall point of view.

It should be pointed out that the above design is obtained under the constraint that the external dimensions remain unchanged. If the thickness of the mirror is allowed to be reduced by 2 mm, then a value of f_{max} smaller than $\lambda/20$ (2.6089×10^{-5} mm) can be obtained.

The maximum stress corresponding to all the results given above is less than 9.8×10^{-3} N/mm^2, which is considerably below the yield limit of the material.

References

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Development of Surface-Tension Tanks on LM-4 Third-Stage Attitude Control Engine

93FE0048A Beijing ZHONGGUO HANGTIAN [AEROSPACE CHINA] in Chinese No 8, Aug 92 pp 28-31

[Article by Zang Jialiang [5258 1367 0081] of Shanghai Institute of Power Machinery: "Development of Surface-Tension Tanks on Long March 4 Third-Stage Attitude Control Engine"]

[Text] **Abstract**

The development of China's first surface-tension storage tank is described. The reasons for selecting this design for the third-stage attitude control engine of the Long March 4 (LM-4) launch vehicle are explained. The design and production of this surface-tension tank as well as the performance and flight test results are summarized.

I. Introduction

A surface-tension tank is a fuel storage container in which the liquid level is controlled by the surface tension of the liquid through the use of screens or other capillary elements.

The surface tension creates a pressure difference ΔP_c at the gas-liquid interface which is primarily the result of interactions between the molecules. ΔP_c can be expressed as

$$\Delta P_c = \sigma(1/R_1 + 1/R_2) \qquad (1)$$

where σ is the surface tension, R_1 and R_2 are the radii of curvature at the gas-liquid interface.

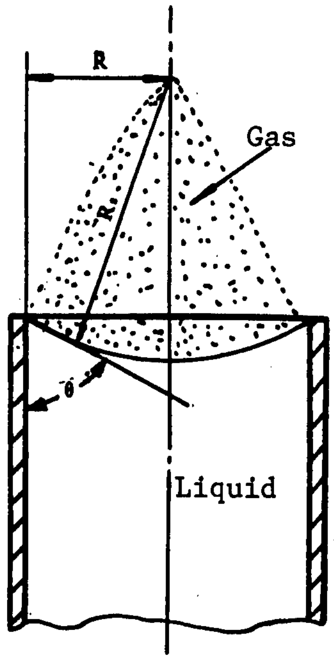

Figure 1. Spherical Gas-Liquid Interface

For a spherical interface (Figure 1), $R_1 = R_2 = R_s$, hence $\Delta P_c = 2\sigma/R_s$.

When the contact angle θ between the liquid and the solid surface is non-zero,

$$\Delta P_c = 2\sigma \cos \theta / R \qquad (2)$$

In general, the contact angle between propellant and the metal container is $\theta = 0°\text{-}2°$. But for hydrazine, θ is typically larger than 10°, and sometimes can be as high as 50°; therefore, the effect of θ must be taken into account.

The pressure difference due to surface tension theoretically can be calculated from equation (2), but in engineering application it is determined by the "bubble point" test. When the first bubble is created by the gas passing through the dampened screen, the front-to-back pressure difference is called the bubble-point pressure difference or simply bubble-point pressure. It reflects the actual load that can be supported by the capillary elements (e.g., the liquid film on the screen); its magnitude depends on the liquid medium used for the test, the shape and size of the screen openings, and the quality of the welded joints. Only if this pressure difference is equal to or greater than the total pressure difference that would destroy the gas-liquid interface will the liquid film remain intact during actual operation; only under such conditions can the propellant be stored reliably in the container and penetration of the pressurized gas through the liquid film be prevented.

From another point of view, the stability of gas-liquid interface in a surface-tension-controlled propellant tank under low gravity and fixed volume is determined by the Bonde (Bo) number; Bo is the ratio of the inertia force to the surface tension of the liquid. It can be proved theoretically that for a circular-hole surface-tension element, the stability condition of gas-liquid interface is Bo ≤ 0.84; for a square-hole element, Bo must be smaller than 0.45. However, test results show that the gas-liquid interface is stable only when Bo $<< 1$, i.e., when the liquid behavior is dominated by surface tension.

The above is a brief description of the basic concept of the surface-tension tank.

Test results have shown that by using surface-tension tanks for liquid-propellant rocket engines, it is possible to achieve gas-liquid separation under weightless (microgravity or zero-gravity) conditions and under conditions where eddies, mixing and sloshing may take place in the propellant. The surface tension of the propellant keeps it at a constant position in the tank and always keeps the exit covered so that a constant supply of "bubble-free" propellant is delivered to the engine.

Surface-tension tanks have been used successfully by other countries on satellites or other spacecraft, but not on launch vehicles. The first surface-tension tank developed in this country is the one used by the third-stage attitude control engine of the LM-4 launch vehicle (Figure 2, Figure 3). While its design, production and testing are based strictly on the unique requirements of the LM-4 mission and China's current technical capabilities, this experience will undoubtedly play an important role in the development of future surface-tension tanks for other applications.

II. Design, Production and Testing of Surface-Tension Tanks

The third-stage attitude-control engine of the LM-4 uses the single-element self-decomposed anhydrous hydrazine (N_2H_4) as propellant. The physical properties of this propellant are such that it requires special measures to prevent it from freezing or overheating. For a period of several tens of seconds, the engine is operating under microgravity or zero-gravity conditions. The required capacity of the tank is only 28L, but the flow rate varies over a wide range, reaching a maximum of 0.32 kg/s. The storage tank is placed at the center of a non-rigid cross beam of the third-stage engine, and a 490-kN swivel engine is attached to each of the two sides of the tank. Hence the engine operates under less favorable dynamic conditions than that of a satellite or other space vehicles.

Unlike some satellites or space vehicles, a launch vehicle is not designed to operate in space for a long duration (in terms of years). In the past, the attitude-control engines of launch vehicles generally used colloidal storage tanks. The reasons for choosing a surface-tension tank design for the LM-4 attitude-control engine are as follows:

(1) The rubber parts of the colloidal storage tank are subject to aging and therefore cannot be stored over long periods; also, its usage is limited because the colloidal

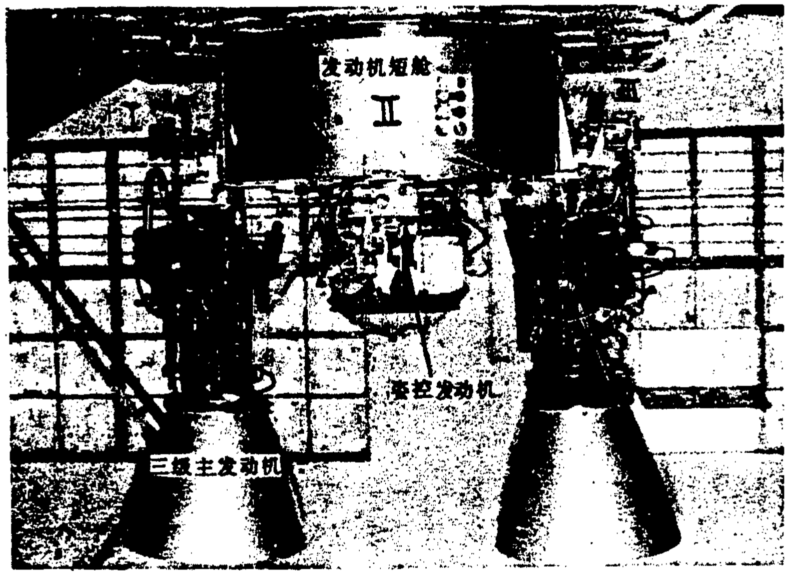

Figure 2. The Third-Stage Main Engine and Attitude-Control Engine of LM-4

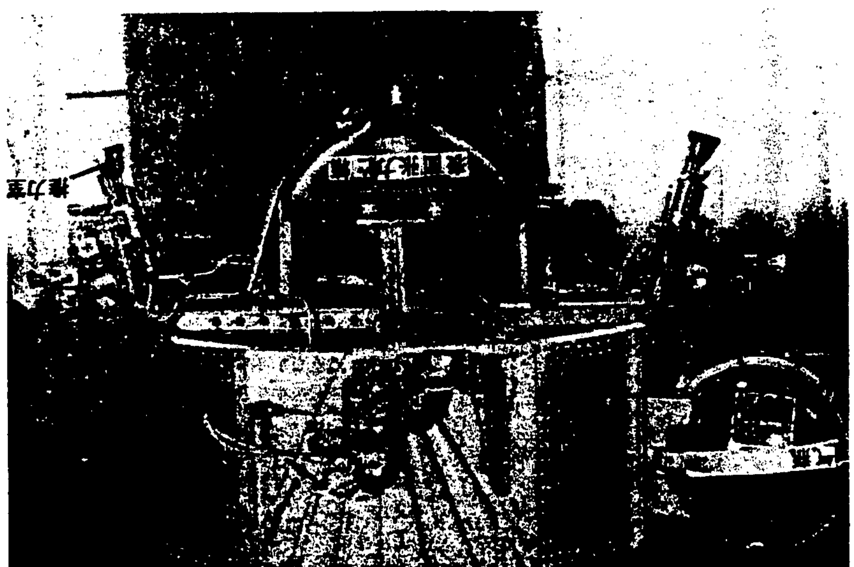

Figure 3. External View of the Assembled LM-4 Third-Stage Attitude-Control Engine

tank is in direct contact with the propellant under filled condition. The surface-tension tank is completely made of metals which can be stored over extended periods and do not react with the propellant.

(2) The manufacturing of colloidal storage tanks requires special molds and tools; its production cycle is long and the production cost is high. Therefore, once produced, changes in the mission requirement cannot be tolerated. In particular, if anhydrous hydrazine is used as the

propellant, it is often necessary to apply external heating which accelerates the aging process and significantly degrades reliability. Under these situations, the tank must be redesigned and manufactured. On the other hand, the surface-tension tank is much more flexible; it can accommodate changes in fill capacity within certain limits. If redesign is necessary, it can be accomplished by shortening or extending the original shell and making appropriate changes in the control unit. Production of special molds and special tools is not required.

(3) The fill capacity of a colloidal storage tank is limited. Increasing the fill capacity beyond 100 kg will introduce considerable difficulties in the design and manufacturing of the tank. Also, the structural weight of the colloidal tank grows rapidly with increasing fill capacity. On the other hand, the fill capacity of a surface-tension tank is quite flexible; as the size of the tank increases, the relative weight of the control unit becomes smaller, and no additional design problems are introduced.

(4) The surface-tension storage tank is considered to be an advanced technology that has never been used on launch vehicles. Applying our research results from the past few years to the third-stage attitude-control engine of the LM-4 launch vehicle would provide an opportunity to verify the design and valuable experience in applying this technology to future launch vehicles and spacecraft.

Having decided on the surface-tension tank configuration, we have established several design guidelines. The first guideline is reliability. Reliability is particularly important for launch vehicles because they are subject to dynamic conditions much worse than those for satellites or other spacecraft; also, the reliability of any new technology must be fully demonstrated before it can be accepted by the aerospace community. The second guideline is to ensure that the use of a surface-tension tank will not adversely affect engine performance. The third guideline is that the design configuration should be sufficiently representative in order to gain wide acceptance. The fourth guideline is to keep the development cost low and the development cycle short in order to meet the goal of developing a product within 2 years under current budget.

The final design of the storage tank is an oblong-shaped structure that can be easily disassembled for inspection and testing (Figure 4). The capacity of the tank is 28L, which clearly classifies it as a small tank. We selected a semi-controlled design which consists of an uncontrolled upper compartment (approximately 60 percent of the total capacity) and a controlled lower compartment; the two compartments are separated by a dividing plate.

The screen of the tank is made of 325 x 2300/sq. in. stainless-steel mesh. The dividing plate has two screens welded to each of the upper and lower sides to improve the resistance against shocks caused by liquid sloshing.

A "trapping device" is installed at the inlet of the storage tank in place of a one-way valve. Its near-zero flow

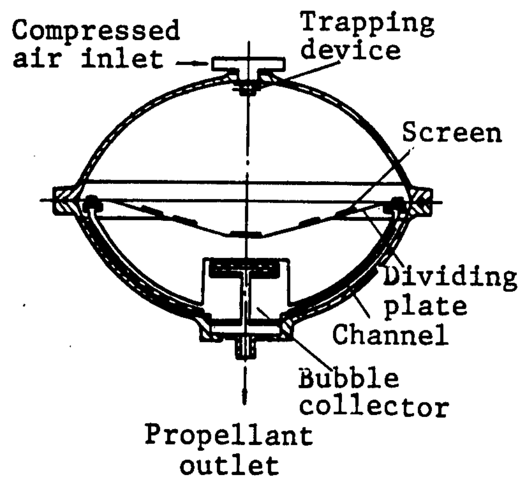

Figure 4. Schematic Diagram of the Surface-Tension Storage Tank

resistance eliminates any potential thrust bias (usually 7.5 percent) that might be introduced.

The most critical step of the manufacturing process is the welding operation of the screens. We used the WG-1 welding machine developed by the Shanghai Xinxin Machine Plant and carefully selected the welding parameters to ensure that the quality of weld meets design requirements.

The storage tank has undergone adequate ground tests, but it has not been tested under weightless conditions using the "drop tower" method or the "parabolic flight in airplane" method. The above methods were replaced by simulation tests because they provide a period of weightlessness too short for meaningful full-scale exhaust tests.

In order to verify the proposed design, a special test was conducted during the first launch of the LM-4 on 7 September 1988. During this test, the attitude-control engine was allowed to continue operation after its mission had been completed, and the engine parameters continued to be telemetered to monitor the engine operating conditions until the propellant inside the tank was depleted. From electric start of the attitude-control engine until depletion of the propellant, there is a period of nearly 100 seconds in which the engine undergoes random starting operations under zero-gravity or microgravity conditions. Therefore, this is a test where the performance of the storage tank can be realistically and fully evaluated under weightless conditions. The pressure in the thrust chamber remains stable throughout the test (which included 67 starting operations under zero-gravity and discharges lasting 50 seconds under microgravity); no large pressure fluctuations or discontinuities were observed. This implies that the propellant supplied to the thrust chamber did not contain "air bubbles," and therefore demonstrates the reliability of the surface-tension tank.

III. Conclusions

The propellant tank of the third-stage attitude-control engine of the LM-4 launch vehicle is the first surface-tension tank developed in this country; the development cycle was 1 year and 8 months, and the cost was only several hundred thousand yuan. Its performance parameters and specifications are comparable to those of advanced foreign designs.

The smaller the capacity of a surface-tension tank, the higher the flow rate and the lower the discharge efficiency. The capacity of the surface-tension tank of the LM-4 third-stage attitude-control engine is only 28L, and the maximum flow rate is 0.32 kg/s; the flow rate-to-capacity ratio is 0.0114 kg/s-L. This value compares favorably with the performance data of surface-tension tanks built in other countries (see Table 1). The bubble-point pressure of the welded parts can be controlled to within a range of 6.5-7.0 kPa (the lowest pressure in a foreign design is 5.526 kPa). During vibration tests where the composite acceleration of the two ends of the tank exceed 981 m/s^2, the tank structure remains undamaged, and the bubble-point pressure basically remains unchanged. This shows that the surface-tension tank can be used on the LM-4 launch vehicle under adverse dynamic conditions; it also demonstrates the reliability of both the quality of weld and the screen structure. At the inlet of the storage tank a trapping device is installed in place of the conventional one-way valve in order to eliminate the thrust bias and to maintain the required values of the performance parameters. Another useful experiment would be to conduct a discharge test of the surface-tension tank on the launch rocket after satellite-rocket separation.

The successful participation of the third-stage attitude-control engine of the LM-4 in the first (1988) and second (1990) launches of the FY-1 meteorological satellite has clearly demonstrated the reliability of the surface-tension tank.

Table 1. Comparison of Performance Parameters of Domestic and Foreign Surface-Tension Tanks

Manufacturer	Tank capacity (L)	Propellant	Flow rate (kg/s)	Flow rate-capacity ratio (kg/s-L)	Discharge efficiency (%)	Bubble-point pressure (kPa)
Shanghai Institute of Power Machinery, Shanghai Xinxin Machine Plant	28	Anhydrous hydrazine	0.320	0.0114	98.14	6.5-7
European Power Equipment Company in France	39	—	0.006	0.00015	98	—
ERNO Company in Germany	240	Nitrogen tetroxide	0.0983	0.00041	99	—
		Methyl hydrazine	0.0595	0.00025		
Douglas Company in U.S.	310	—	0.0536	0.00173	98	≥ 5.525
Martin Marietta Corporation in U.S.	470	Nitrogen tetroxide	5.88	0.0125	97.6	≥ 5.525
		Methyl hydrazine	3.69	0.00785		

Application of Fuzzy Waveform Analysis to Aircraft Target Recognition

93FE0048C Shenyang XINXI YU KONGZHI [INFORMATION AND CONTROL] in Chinese Vol 21 No 4, Aug 92 pp 244-247

[Article by Lu Hanqing [4151 3352 3237] of the Chinese Academy of Sciences, Institute of Automation, National Pattern Recognition Laboratory, Beijing 100080, Peng Jiaxiong [1756 0857 7160] and Wan Faguan [5502 4099 6306] of Central China Science & Engineering University, Institute of Pattern Recognition and Artificial Intelligence, Wuhan 430074: "Application of Fuzzy Waveform Analysis to Target Recognition"; MS received 5 Oct 91]

[Text] **Abstract**

This paper introduces a waveform analysis method in which the membership function is used to provide a quantitative measure of the peaks and valleys of a given waveform. By expressing the waveform as a fuzzy set, recognition and classification can be carried out using dynamic alignment of the fuzzy set. Tests show that this method is effective in performing rapid recognition and classification of two-dimensional targets. In this paper, results of applying this method to the recognition of aircraft targets are presented.

1. Introduction

The analysis of a planar, hole-free target can be reduced to a simpler problem of one-dimensional contour-sequence analysis.[1-6] One representation of the contour sequence is expressed in terms of the Euclidean distance from the center of the target to a point on the contour. Graphically, the distance sequence can be plotted as a

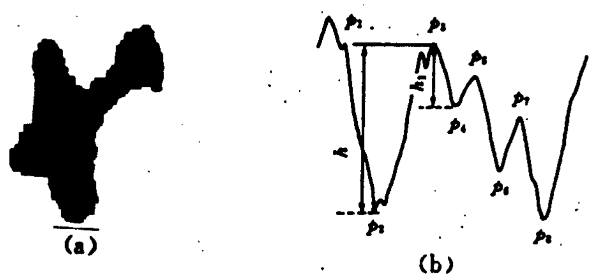

Figure 1. Contour of the Aircraft Target and Its Edge-to-Center Distance Curve

slowly varying waveform curve; as shown in Figure 1, the contour of the aircraft of Figure 1(a) is represented by the distance-sequence curve of Figure 1(b). The most notable features of the waveform of Figure 1 are its peaks and valleys (extreme points); in this paper, a membership function which provides quantitative measure of these peaks and valleys is introduced, and a fuzzy-set waveform analysis method is presented.

2. Fuzzy-Set Representation of the Values of Peaks and Valleys

The values of peaks and valleys of the edge-to-center distance waveform are indicated in Figure 1(b); it can be seen from the figure that while both p_1 and p_3 are peak values, the likelihood of p_1 being a true peak is greater than that of p_3. In this paper, we attempt to provide a quantitative measure of this difference by introducing the concepts of fuzzy sets and membership.

An examination of the waveform in Figure 1(b) shows that the ability to identify a peak depends not only on the peak value itself but also on the values of two neighboring valleys; the same rule applies to the identification of a valley. The likelihood of the peak value p_3 being identified as a peak does not depend on h but only on h_1. Further examination shows that the degree of membership increases with increasing h_1; therefore, the peak-valley membership should be a monotonically increasing function, as shown in Figure 2. The x-axis in the figure represents the absolute value of the smallest difference between the distances from the peak to the two neighboring valleys, and $\mu(x)$ denotes the peak-value membership function of x.

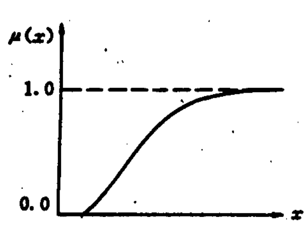

Figure 2. A Model of Membership Function

Let $\mu(x)$ be expressed by a rising semi-normal distribution:

$$\mu(x)\begin{cases} 0, & x \leqslant a; \\ 1-e^{-k(x-a)^2}, & x > a \end{cases} \quad (1)$$

where a,k are two constants to be determined ($a \geq 0$, $k > 0$).

Once $\mu(x)$ is determined, the peak-valley fuzzy set of the waveform s can be expressed as follows:

$$\underset{\sim}{A} = \{\mu(x_i)/p_i \mid i = 1, 2, \cdots, n\} \quad (2)$$

where p_i denotes the value of the ith peak (valley), x_i denotes the absolute value of the smallest difference between the distances from the ith peak to its two neighboring valleys, and $\mu(x_i)$ denotes the likelihood that p_i would be actually identified as the peak (or valley).

We shall now discuss the selection of the constants a and k. It has been pointed out earlier that certain peak values of the discretized waveform are either too small to be of any significance or are actually caused by noise. These small peaks and valleys are of no interest in this analysis; in order to remove these points, one can select the appropriate value of a so that the likelihood (degree of membership) of the peaks and valleys is assigned the value "0." Through experimentation, one can determine an appropriate value x_1 to give $\mu(x) = 0.9$; thus,

$$1 - e^{-k(x_1-a)^2} = 0.9 \quad (3)$$

from which one can solve for k:

$$k = \frac{1}{(x_1 - a)^2 \log e} = \ln 10/(x_1 - a)^2 \quad (4)$$

In order to ensure that variations in the amplitude of the waveform do not affect the value of $\mu(x)$, both x_1 and a are chosen to be functions of the mean value of the waveform, so that the ratios between x_1, a and the mean waveform are constants. If the discretized waveform sequence is $s = s_1, s_2, \ldots, s_N$, then its mean value is

$$\bar{s} = \frac{1}{N}\sum_{i=1}^{N} s_i \quad (5)$$

and x_1 and a can be expressed as

$$\begin{cases} a = \alpha \cdot \bar{s} \\ x_1 = \beta \cdot \bar{s} \end{cases} \quad (6)$$

where α, β are both constants.

By substituting equations (4), (6) into (2), one can show that when the waveform amplitude varies, the peak and valley membership remains unchanged.

3. Recognition by Dynamic Matching

Since the edge-to-center distance sequence is not affected by a translation of the target contour, the fuzzy set is displacement-invariant. A change in the scale of the target contour will not affect the appearance and the order of the peaks and valleys, it only introduces a proportionality constant to their amplitudes; but as pointed out earlier, this effect has been removed in the membership function, hence the fuzzy set is also scale-invariant. A rotational change in the target will cause cyclical shifts in the peaks and valleys, but the relative positions remain unchanged. This will be taken into consideration in the recognition process.

A quantitative measure of the peaks and valleys of the waveform has been given in the previous section; thus every waveform to be recognized and every template waveform can be expressed by a fuzzy set. The problem of waveform recognition is then reduced to the problem of matching two fuzzy sets.

Let the two fuzzy sets be [from here on in text, all A,B have a tilde under the letter]

$$\underset{\sim}{A}=\{\mu_a(i)/a_i\,|\,i=0,1,\cdots,n-1\} \quad \text{and}$$

$$\underset{\sim}{B}=\{\mu_b(i)/b_i\,|\,i=0,1,\cdots,n-1\}$$

and let D(A,B) be the mismatch function of A and B, defined by:

$$D(\underset{\sim}{A},\underset{\sim}{B}) = \min_k d_k(\underset{\sim}{A},\underset{\sim}{B}) \qquad (7)$$

where

$$d_k(\underset{\sim}{A},\underset{\sim}{B}) = \sum_{j=0}^{n-1} |\mu_a(j) - \mu_b(j+k)| \qquad (8)$$

and the term (j+k) in equation (8) indicates an addition operation for mode n.

The mismatch function D(A,B) is a measure of the similarity between A and B; the smaller D(A,B) is, the more similar are A and B; if D(A,B) = 0, then A = B.

If there are m templates, denoted by A_1, A_2, ..., A_m, and let the fuzzy set of the peaks and valleys of the waveform be B, then B is classified to be type j if

$$D(\underset{\sim}{B},A_j) = \min_k D(\underset{\sim}{B},A_k) \qquad (9)$$

The above discussion did not take into consideration interference effects due to noise; in practice, these effects, which are always present, may produce false peaks in the waveform and may also cause some small peaks to vanish. If equation (7) is used directly to calculate the mismatch function without considering these effects, it may lead to erroneous results. To overcome this shortcoming, we divide the waveform into two regions: the main-peak region and the perturbation region. The main-peak region refers to the region containing large-amplitude peaks and valleys; the perturbation region refers to a region containing many small peaks. We also define a function $\mu_1(x)$ which is a measure of the likelihood of classifying the perturbation region as the main-peak region. To be classified as a main-peak region, the perturbation region must satisfy the following conditions:

(1) The membership functions of all the peaks and valleys in the perturbation region are small; in this paper, they are defined to be $\mu(x) \leq 0.1$.

(2) The widths of all the peaks and valleys in the perturbation region are small.

In other words, only those perturbation regions with small peaks and small inter-peak distances can be classified as main-peak regions. When a perturbation region is classified as a main-peak region, its membership function $\mu(x)$ must be re-computed in the matching recognition process.

The second condition which implies that several small peaks in the perturbation region may be combined into a single main peak is reflected in the membership function $\mu_1(x)$. $\mu_1(x)$ is a measure of the likelihood that two adjacent peaks (or valleys) in the perturbation region may be combined into a single peak (or valley); it varies inversely with the inter-peak distance x, and can be expressed in the form:

$$\mu_1(x) = e^{-k_1 x} \qquad (10)$$

Assume that $\mu_1(x_0) = 0.9$ when $x = x_0$, then

$$k_1 = 1/x_0 \ln 9 \qquad (11)$$

The value of x_0 is determined empirically.

4. Test and Analysis

The method presented in this paper has been applied to the recognition of aircraft targets with promising results (see Figure 3 and Figure 4). The membership functions of the peaks and valleys re shown in Table 1, and a set of test values are given in Table 2. For each target, three representative switches are chosen; the degree of mismatch of each case with the four template waveforms is presented in Table 2. It can be seen that although the edge-to-center distance waveforms of these four aircraft are quite similar (particularly between type 1 and type 2), this recognition method still produces satisfactory results with more than 90 percent correct classification.

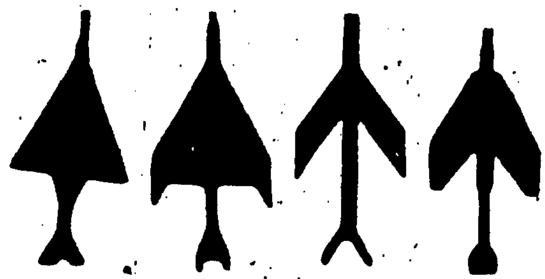

Figure 3. Four Different Aircraft Targets

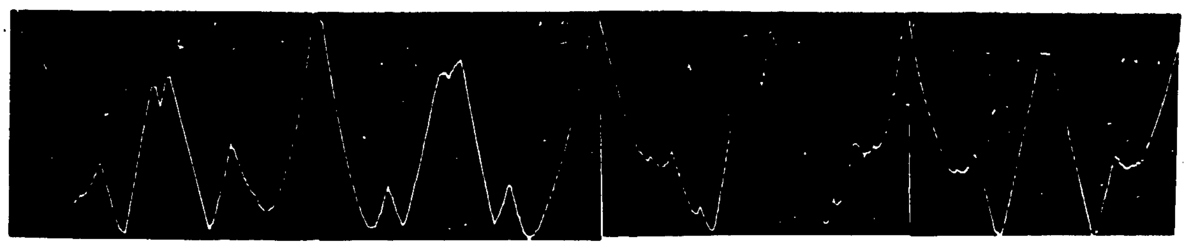

Figure 4. Edge-to-Center Distance Sequence Waveforms

Table 1. Fuzzy Set Template

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	.2375	.1410	.1410	.0105	.0105	.0178	.1285	.1285	.2073	.9865				
2	.3151	.3151	.4861	.0359	.0359	.0484	.4687	.3568	.3568	.9817				
3	.1151	.1151	.0527	.0527	.1925	.3971	.2460	.2460	.1905	.0199	.0199	.0039	.0039	.9879
4	.2155	.2155	.7684	.9961	.6601	.0134	.0134	.9781						

Table 2. Fuzzy Set Mismatch

	1	2	3	4
1	.1572	1.2480	2.5327	3.2797
1	.2828	1.2113	2.5255	3.3068
1	.5059	1.2878	2.2600	1.4340
2	1.6870	.2956	2.2408	3.2748
2	1.5847	.6148	2.1355	3.1328
2	1.5385	1.0298	2.2342	3.6258
3	2.5581	2.4161	.9443	1.5053
3	2.6512	2.5188	.7542	1.2157
3	2.4990	2.3590	.5757	1.2454
4	1.6726	1.6007	1.4313	.8105
4	1.7938	1.7258	1.0241	.4145
4	1.7145	1.6425	1.6323	.5155

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Minimum-Time Control of Aeroassisted Orbital Transfer Vehicle

40100035A Beijing YUHANG XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 4, Oct 92 pp 9-16

[English abstract of article by Jing Wuxing, Yang Di, and Wu Yaohua of the Harbin Institute of Technology, Harbin, 150006; MS received 29 Dec 90]

[Text] The minimum-time control of aeroassisted orbital transfer vehicle (AOTV) which arises in the study of coplanar HEO-LEO orbital transfer is considered. The open-loop optimal control law is derived by means of Pontriagin's maximum principle. An example in which the AOTV transfers from geosynchronous orbit to coplanar 500-kilometers-high circular orbit is simulated in which atmosphere density is based on the US.62 Standard Atmosphere. The simulation result shows that the characteristic velocity change required by aeroassisted orbital transfer is only 43.8 percent of that required by Hohmann transfer. The controlled flight time is about 20 minutes.

Scattering Characteristics of a Large Perfectly Conducting Finite-Length Circular Cylinder

40100035B Beijing YUHANG XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 4, Oct 92 pp 26-34

[English abstract of article by Chen Zhongfei of the Eighth Design Institute of Shanghai Aerospace Bureau, Shanghai, 200233, and Fu Guoxing of the University of Electronic Science and Technology of China, Chengdu, 610054; MS received 8 May 91]

[Text] Using uniform geometrical theory of diffraction (UGTD) and physical optics method (POM), the scattering characteristics of a large perfectly conducting finite-length circular cylinder are presented here. First- and second-order diffractions are included, while stationary approximations are used in the vicinities of specular reflecting directions. Measurements are also made, and the experimental results agree with the theoretical ones very well.

Recrystallization Nucleation, Its Role in the Superplastic Deformation of Al-Li Alloy

40100035C Beijing YUHANG XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 4, Oct 92 pp 69-72

[English abstract of article by Liu Zhiyi, Cui Jianzhong, and Bai Guangrun of Northeast University of Technology, Shenyang, 110016; MS received 17 Apr 91]

[Text] Under the optimum condition of superplastic deformation (T = 500°C, ε[dot]$_i$ = 3.33 + 10^{-3} s^{-1}) in Al-1.91 Li-1.25 Cu-0.46Mg-0.21Zr alloy, three kinds of recrystallization nucleation occur: 1) nucleation by bulge of subgrain boundary, 2) nucleation by widening of subgrain boundary, 3) nucleation by bulge of high angle boundary. It is indicated that all these kinds of recrystallization nucleation release the stress concentration at triple junction led by grain boundary sliding. In addition, the first and the second kind of nucleation refine grains, but the last one causes grain growth. Recrystallization nucleation by bulge of high angle boundary is promoted by a large amount of particles present in the vicinity of the grain boundary.

System Management Program Implementation of a Reconfigurable Double-Computer System at Module Level

40100036A Beijing ZHONGGUO KONGJIAN KEXUE JISHU [CHINESE SPACE SCIENCE AND TECHNOLOGY] in Chinese Vol 12 No 5, Oct 92 pp 13-17

[English abstract of article by Wang Shuhua of Beijing Institute of Control Engineering; MS received 25 Feb 92]

[Text] The active state number of a double-computer system which is reconfigurable at module level is analyzed and compared with other redundant configuration computer systems which are spare standby at system level. The results show that the lower the redundancy level is, the higher the reliability is, and the larger the active state number is. This will increase the complexity of management software. This paper introduces the design principles of management software and briefly describes the features of some subroutines.

Techniques for Development of Carbon/Epoxy Stringer Preforms of a Corrugated Cylinder for Satellites

40100036B Beijing ZHONGGUO KONGJIAN KEXUE JISHU [CHINESE SPACE SCIENCE AND TECHNOLOGY] in Chinese Vol 12 No 5, Oct 92 pp 18-26

[English abstract of article by Shi Yong of Beijing Spacecrafts; MS received 9 Mar 92]

[Text] The development of carbon/epoxy stringer preforms of a corrugated cylinder for a certain type of satellite is discussed. The change of the properties of the resin matrix during curing process is studied by using a method called Dynamic Dielectric Analysis (DDA) to determine the optimum technological parameters for prebleeding of the prepreg and precompaction of the preforms. The curing degree of the preforms is also determined using the dielectric loss curves. The forming of the preforms is carried out on a soft-hard sectional die and the preforms developed satisfy the requirements of the manufacture of the carbon/epoxy corrugated cylinder, which passed the ground mechanical tests later.

Radiation Calibration of Scanning Radiometer for Meteorological Satellite

40100036C Beijing ZHONGGUO KONGJIAN KEXUE JISHU [CHINESE SPACE SCIENCE AND TECHNOLOGY] in Chinese Vol 12 No 5, Oct 92 pp 27-33

[English abstract of article by Zhu Guangze of the Meteorology Satellite Center, SMA; MS received 1 Aug 91]

[Text] The radiation calibration of scanning radiometer for a meteorological satellite is stated in this paper, including the pre-launch calibration, in-flight calibration and the absolute calibration through comparison between the data ground measured and the data transmitted from the satellite. It is noted that the calibration for visible waveband can not yet be used for operational satellite and is still in research stage. Radiation calibration for a geostationary satellite can only be a relative one. Therefore we must find an objective target as a calibration source to resolve the problem of absolute calibration. In this way the data transmitted from satellite will be effective even if the calibration equipment on the satellite has failed.

Low-Loss 14/12 GHz FET Mixer

40100036D Beijing ZHONGGUO KONGJIAN KEXUE JISHU [CHINESE SPACE SCIENCE AND TECHNOLOGY] in Chinese Vol 12 No 5, Oct 92 pp 66-70

[English abstract of article by Chen Mingzhang of Xi'an Institute of Space Radio Technology; MS received 20 Apr 92]

[Text] The principle and design method of a field effect transistor (FET) mixer are introduced. A single-ended FET mixer is fabricated. The mixer operates in frequency range 14.0-14.5/11.7-12.2 GHz with-0.36 dB conversion loss, 5.6 mW local oscillator power, less than 0.8 dB loss variation in 500 MHz band and 14.2 dB noise figure.

500 KLIPS Intelligent Coprocessor Board Developed by BUAA

93P60076A Beijing GUOJI HANGKONG [INTERNATIONAL AVIATION] in Chinese No 10, Oct 92 pp 17-18

[Article by Yin Baolin [1438 1405 2651], Li Wei [2621 2607], and Zhao Qinping [6392 3084 1627]: "Intelligent Computer Research at BUAA"]

[Summary] As part of the State 863 High-Tech Plan (Intelligent Computer Systems area), engineers at Beijing University of Aeronautics & Astronautics (BUAA) have developed the PLC system, an intelligent coprocessor board which can be inserted into a Sun-4 workstation to run both Prolog and Common Lisp programs with a peak speed of 800 KLIPS (thousand logical inferences per second) and an average speed of 500 KLIPS. The PLC system incorporates 29300-series bit-slice processors as the main operating and control units and four varieties of independently designed 6-slice very-large-scale ASICs with an integration level of 5000-8000 gates per chip. Two of these ASIC varieties are used in the stack controller, designed with semi-custom VLSI technology; an independently designed AISCE [as published; ?ASICE] system with 1.2-micron fabrication rules was used for this design. The other two ASIC varieties, for the instruction preprocessor and the heap controller, were trial-manufactured via FPGA [field-programmable gate array] technology.

More Reports on U.S. Firms in China Market

7 New Sino-Foreign Joint Ventures in Beijing

93P60062A Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 40, 14 Oct 92 p 1

[Article by Xiao Yan [2556 3601]: "Steps Hasten Reform and Opening Up, Create Benevolent Investment Environment"]

[Summary] On 6 October in the Beijing International Hotel, the Beijing Municipal Electronic Office Systems organization signed contracts for seven new Sino-foreign joint ventures (JVs) at a ceremony attended by Mayor Chen Xitong. This organization has now set up 80 Sino-foreign JVs involving a total of US$860 million, of which $330 million is foreign capital. The seven new JVs are as follows:

1. The Sino-U.S. JV AT&T Fiber Optic Cable Ltd., with a gross investment of US$12.60 million; this firm will market the LXE bundle-tube lightweight fiber optic cable product series and other related products.

2. The Sino-Korean JV Beijing Shifeng [0013 0023] Electronics Ltd., with a gross investment of US$1.04 million; this firm will market automobile sound systems.

3. The Sino-U.S. JV Beijing Sanlian [0005 5114] Electronics Ltd., with a gross investment of US$730,000; this firm will design, manufacture, and sell large-scale integrated (LSI) circuits.

4. The Sino-U.S.-Hong Kong JV UNIX Systems Technology Ltd., with a gross investment of US$1.2 million; this firm will develop, design, manufacture, and sell computer software and computer systems integration services.

5. The Sino-Hong Kong JV Beijing Lianxing [5114 5281] Electronics Ltd., with a gross investment of US$170,000; this firm will develop, manufacture, and sell language, communications, and control systems and digital/Chinese-character-compatible radio pager coding systems.

6. The Sino-U.S. JV Beijing Jihua [2111 5478] Information Ltd., with a gross investment of US$250,000; this firm will develop, manufacture, and sell computer systems software.

7. The Mainland-Taiwan JV Chuanzheng [0278 1767] Information Services Ltd., with a gross investment of US$200,000; this firm will edit the monthly magazine XINXI YU DIANNAO [INFORMATION AND COMPUTERS].

Of the foreign investment funds, U.S. firms—among which AT&T and USL are prominent—account for 57 percent.

SGI, Yunnan Plant Form Shenzhen Huaqi Computer Ltd.

93P60062B Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 40, 14 Oct 92 p 2

[Article by Li Liangyu [2621 5328 3768] and Chen Dazhi [7115 1129 1807]: "Tracking the International State-of-the-Art Graphics Technology—Sino-U.S.-Hong Kong Joint Venture Huaqi Formed"]

[Summary] Shenzhen Huaqi [5478 1142] Computer Ltd., a Sino-U.S.-Hong Kong computer joint venture formed by the U.S. firm SGI [Silicon Graphics Inc.], the Yunnan Electronic Equipment Plant, and four other parties, was formally established on 23 September in Beijing. Simultaneously, SGI announced at a press conference its first marketing of the R4000 IRIS Indigo workstation series and Reality Engine graphics card to mainland Chinese users [see earlier report in JPRS-CST-92-022, 18 Nov 92 pp 9-10]. Shenzhen Huaqi Computer Ltd.'s primary objectives are to import the most advanced foreign technology in the area of visual operations and 3-D graphics in order to domestically assemble and manufacture 90s state-of-the-art graphics workstations, to import and develop workstation applications software products, and to provide systems engineering design and systems integration services.

Yuji Electronics Ltd., Microsoft Cooperate

93P60062C Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 43, 4 Nov 92 p 5

[Article by Liu Jiuru [0491 0046 1172]: "Yuji, Microsoft Unfold Plans for Full Cooperation"; cf. JPRS-CST-92-022, 18 Nov 92 p 9]

[Summary] Yuji [5940 1015] Electronics Ltd. and the U.S. firm Microsoft Corp. have announced plans to develop full cooperation. The two firms recently concluded general agent agreements in Beijing for the China Mainland Microsoft Authorized Training Center, the Shenzhen (Guangzhou) and Shanghai Microsoft Software Sales Centers, and the China Mainland Microsoft Press.

Sun, Shanghai Plant Hold Exhibition

93P60062D Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 43, 4 Nov 92 p 5

[Article by Li Liangyu [2621 5328 3768]: "Shanghai Holds Sun Workstation Applications Exhibition"]

[Summary] The U.S. firm Sun Electronic Computer Corp. and the Shanghai Electronic Computer Plant recently held the SUN'92 Autumn Computer Applications Exhibition in Shanghai. At the exhibition, Sun unveiled its 2GX advanced SPARC workstation and the SS2 GS workstation series, and also introduced its newly developed (1992) SPARCstation 10 high-performance [multiprocessor] workstation, with a single-processor speed of 86 MIPS.

AT&T/NCR

93P60078A Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 44, 11 Nov 92 p 3

[Article by Mu Zishi [2606 1311 4258]: "AT&T/NCR Expands Cooperative Business in China"]

[Summary] In order to expand its cooperative business in China, the U.S. firm AT&T/NCR in late October formally established a branch office in Shanghai, following upon other offices set up by the firm in Beijing and Guangzhou. Simultaneously, AT&T/NCR held a 2-day course of technology lectures open to all commercial representatives and individual computer users throughout China. New AT&T/NCR computer and networked communications products were unveiled, including the NCR 3000 computer series, the Starsentry network management system, the NCR ATM 56xx series of fourth-generation counter-type banking machines, the Oracle RDBMS [relational database management system] which runs on the NCR 3000 series of computers, the NCR 3445 server, and the Starstation 386/33 high-performance low-cost platform-style microcomputer with distributed network environment.

Cray Research

93P60078B Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 45, 18 Nov 92 p 3

[Article by Shen Haiying [3088 3189 5391]: "Cray Installs Four S-MP/11 Computers in China"]

[Summary] At a press conference held in Beijing on 27 October, U.S. supercomputer maker Cray Research announced that—via Prosten Technology Co., Cray's only retail firm in China—it is installing four of its S-MP/11 minisupercomputers, one each at Beijing University, Beijing University of Aeronautics & Astronautics, Jilin University, and Dalian University of Technology. The Cray S-MP/11 series comes with a maximum of eight 15-nanosecond high-performance SPARC scalar processors, each providing a 64-bit performance of 67 MIPS and 20 MFLOPS. The S-MP can also be configured with two vector processors and contains at least two added parallel processors. Each vector processor provides a 64-bit performance of from 67 MFLOPS up to 267 MFLOPS. Each of the powerful added parallel processors can be configured with a maximum of 84 Intel i860 processors. With four SPARC scalar processors, two vector processors, and two added parallel processors, the Cray S-MP can deliver a maximum floating-point performance of 6.4 GFLOPS.

Radar Experts Discuss Counter-Stealth Technologies

93P60064C Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 26 Oct 92 p 6

[Article by Jiang Deqing [1203 1795 3237]: "Radar Experts Assemble in Hefei To Discuss Counter-Stealth Technologies"]

[Summary] In late September, a group of nationally recognized radar experts including Bao Zheng, Zhang Guangyi, Huang Huai, Sun Longxiang, and Huang Weizhuo assembled in Hefei to discuss counter-stealth technologies and to conduct technical evaluations of various counter-stealth projects to be studied domestically in the next few years. The main research projects evaluated are titled "Study of Thinned-Array Synthetic Pulse Aperture Radar Counter-Stealth Technology," "Study of a Guidance-Radar Composite Network Counter-Stealth Concept and Feasibility," and "CW Radar Counter-Stealth Feasibility Study." The radar experts also discussed policy and made recommendations for counter-stealth research for the nation's air defense systems.

Fudan University Develops New GeSi Heterojunction Far-IR Detector

93P60080a Beijing ZHONGGUO KEXUE BAO [CHINESE SCIENCE NEWS] in Chinese 17 Nov 92 p 2

[Article by Fu Hong [0265 4767]: "Fudan University Develops New Germanium Silicon Heterojunction Far-Infrared Detector"]

[Text] Fudan University's Applied Surface Physics Key State Laboratory, with the cooperation and support of relevant work units, has developed a new germanium silicon (GeSi) heterojunction far-IR detector, fabricated via a molecular beam epitaxy technique integrated with a Si planar technique. Far-IR detectors operating in the 8-12-nanometer (nm) band have seen important applications in technologies such as remote sensing, guidance, and night vision. Especially after the Persian Gulf War, they have been critically studied by high-tech circles in a number of countries. Testing of this far-IR detector developed by Fudan University shows that the interface boundary barrier height is 0.01 eV, with an estimated corresponding operating wavelength of 2-12 nm. Moreover, with this GeSi heterojunction IR detector, an actual device with a block-body D [detectivity] at the 180 cm-$Hz^{1/2}$/W level has been successfully developed for the first time.

CAS Institute Develops Tunable Ti:Sapphire Laser Crystal

93P60064A Beijing ZHONGGUO KEXUE BAO [CHINESE SCIENCE NEWS] in Chinese 13 Oct 92 p 2

[Article by Huang Xin [7806 6580]: "CAS Shanghai Institute of Optics & Fine Mechanics Develops High-Quality Ti:Sapphire Tunable Laser Crystal"]

[Summary] The high-quality (high structural integrity and high optical uniformity) tunable Ti:sapphire laser crystal developed as an 863 Plan high-tech project by a CAS Shanghai Institute of Optics & Fine Mechanics (SIOFM) team led by Research Fellow Deng Peizhen [6772 0160 3791] passed formal technical appraisal a few days ago in Shanghai. This wideband tunable (660-1200 nm range) laser crystal has numerous applications in frequency doubling and mixing technologies for ultra-short-pulse high power lasers and amplifiers. Heretofore, only the United States and a few other developed nations have been able to grow this crystal. The crystals grown by the SIOFM scientists via their induced thermal-field up-shift [IFUS] technique are 55 mm in diameter and 50 mm in height, and those grown via a vertical temperature step technique are 100 mm in diameter and 50 mm in height.

More on CCD R&D Line at Institute 44

93P60064B Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 14 Oct 92 p 1

[Article by Han Lianguo [7281 6647 0948]: "Nation Constructs First Charge-Coupled Device Research & Development Line"; cf. earlier report in JPRS-CST-92-016, 20 Aug 92 p 18]

[Summary] To hasten the transfer of scientific research achievements in the charge-coupled device (CCD) area into the industrial production-oriented sector, the State has allocated 80 million yuan for the construction of a CCD R&D Center at MMEI's Institute 44 [in Chongqing] as well as for the nation's first CCD R&D line. CCD technology has been targeted by MMEI as a key Eighth 5-Year Plan priority, and Institute 44 has already developed 128-, 512-, 1024-, 2048-, 1728-, and 2500-pixel linear array CCDs that have been incorporated into practical systems, and has developed six varieties of planar array CCDs, including 108 x 100, 150 x 200, and 300 x 230 arrays, some of which have seen practical applications. According to plans, the new construction will permit the institute to annually introduce six new CCD product varieties, which will then be manufactured at the Sino-U.S. joint venture firm Huajing [5478 5464] Image Sensors Ltd., part of the Chongqing Huashu Optoelectronics Group; annual production is to be 2-4 million CCDs. It is understood that representatives from firms in Hong Kong, Taiwan, and Canada have expressed interest in obtaining these new CCD products.

Adaptive Optics Technology Is World-Class

93P60064D Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 30 Oct 92 p 1

[Article by Han Yuqi [7281 3768 3825]: "Nation's Adaptive Optics Technology Enters World's Front Ranks"]

[Summary] The "21-element adaptive optics stellar target imaging compensation system" recently developed as an 863 Plan high-tech project by the CAS Institute of Optoelectronics has propelled the nation into third place in the world—behind the United States and Germany—in the ability to implement stellar target adaptive optical correction in real time. This system, which was formally certified by the CAS on 29 October, consists of real-time wave-front sensors, high-speed deformable mirrors, and a multi-circuit high-speed control system, and permits resolution close to the diffraction limit. In addition to space target imaging recognition, the new system also has applications in high-resolution astronomical observation and laser beam quality improvement.

Novel High-Power COIL Described

93FE0059A Beijing WULI [PHYSICS] in Chinese Vol 21 No 7, Jul 92 pp 385-390

[Article by Bi Ailian [3968 1947 5571], Zhang Rongyao [1728 2837 5069], Chen Fang [7115 2455], and Zhuang Qi [8369 3823] of the CAS Dalian Institute of Chemistry and Physics, Dalian 116023: "Novel High-Power Laser—COIL"]

[Text] **Abstract**

The chemical oxygen-iodine laser (COIL) has recently attracted a great deal of attention in high-power laser research. The basic principle of the COIL is described. We point out that the key to improving the performance of COIL is to enhance the efficiency of the $O_2(^1\Delta)$ chemical generator. Potential applications of COIL are reviewed. Industrial applications may be an important area for the near and intermediate term. Finally, progress in the study of the COIL at Dalian Institute of Chemistry and Physics of the Chinese Academy of Sciences (CAS) is presented.

[Introduction]

A chemical laser is a type of laser in which particle inversion of the excited medium is achieved in the course of a chemical reaction. The chemical oxygen-iodine laser (COIL) is a novel high-power chemical laser discovered after the HF/DF chemical laser. It has numerous advantages, including shorter wavelength (1.315 μm), higher efficiency, better beam quality and higher energy storage. Moreover, it is safe and convenient to use. Therefore, it has a bright future in a variety of applications. Because its wavelength is located in the low-transmission-loss band of the optical fiber already in mass production, there is some work in progress overseas on coupling this laser with an optical fiber for applications such as metal cutting, welding and optical communications.

The COIL can operate in either continuous-wave (CW) or pulse mode. In the pulse mode, the coupling between laser and target can be improved. By means of frequency doubling or tripling with non-linear crystals or resonance enhanced atomic vapor, it is possible to convert the 1.315 μm laser output to the visible band.

Since the development of the first CW COIL by the USAF Weapons Laboratory in 1978,[1] investigations on the COIL have been carried out in the United States, USSR, China, France and Japan. A large-scale (35 kW) CW COIL has been constructed by the United States. The CAS Dalian Institute of Chemistry and Physics (DICP) has also conducted a great deal of research on the COIL.

I. Basic Principles of the COIL

As shown in Figure 1, the COIL primarily relies on a chemical reaction to produce excited $O_2(^1\Delta)$ molecules. Energy is transferred from $O_2(^1\Delta)$ to ground-state iodine atoms $I(^2P_{3/2})$ by way of resonance to produce excited iodine atoms $I^*(^2P_{1/2})$. Finally, population inversion of $I^*(^2P_{1/2})$ is achieved to produce the 1.315 μm laser output.[1,2]

$$O_2(^1\Delta) + I(^2P_{3/2}) \underset{k_2}{\overset{k_1}{\rightleftharpoons}} O_2(^3\Sigma) + I^*(^2P_{1/2}) \qquad (1)$$

$$I^*(^2P_{1/2}) \longrightarrow I(^2P_{3/2}) + h\nu \qquad (2)$$

Obviously, a chemical energy source, i.e., the production of $O_2(^1\Delta)$, must be available in order to produce this iodine laser. Next, we need ground-state iodine atoms to transfer the energy in order to generate excited iodine atoms. Finally, population inversion of excited iodine atoms must be obtained before a specific laser gain can be created. These three areas will be discussed as follows.

1. Chemical Production of Excited-State Oxygen

Since the laser output of a COIL depends on the energy transfer from excited oxygen to atomic iodine, effective production of excited oxygen molecules thus becomes a key issue. There are many ways to produce excited oxygen molecules. Besides chemical production, it can also be done by electron discharge, microwave discharge, direct nuclear pumping and photo-decomposition of O_3. However, excited oxygen molecules for a COIL can only be produced chemically because this is the only method that can produce a concentration of excited oxygen molecules sufficient to reach the threshold for a COIL. Since the energy source of the oxygen-iodine laser is chemical, from a general sense, it is considered to be a chemical laser.

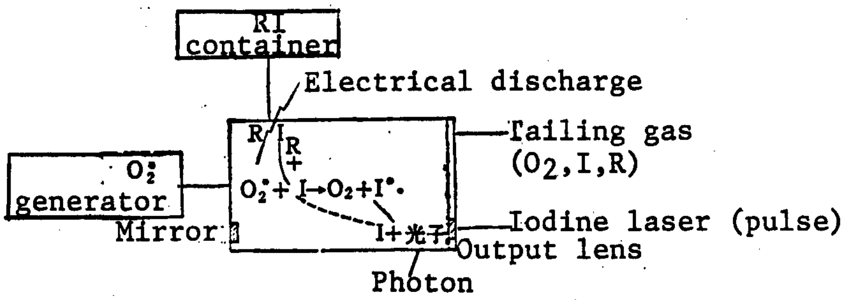

Figure 1. Schematic Diagram of COIL

The chemical reaction used to generate excited oxygen involves passing Cl_2 through a hydrogen peroxide solution. The reaction is as follows:

$$Cl_2 + 2NaOH + H_2O_2 \rightarrow O_2(^1\Delta) + 2NaCl + 2H_2O \quad (3)$$

The reaction yields 100 percent $O_2(^1\Delta)$. In reality, reaction (3) does not take place in either gas or liquid phase. Instead, it occurs at the gas-liquid interface of Cl_2 and H_2O_2-NaOH. Furthermore, $O_2(^1\Delta)$ has a very short life in the liquid phase, approximately 2 μs. In the gas phase, its lifetime is 45 minutes. Therefore, the generator is often designed to ensure that once generated, $O_2(^1\Delta)$ can escape from the liquid film to the gas phase. The reaction byproduct H_2O and remaining H_2O_2 have a strong quenching effect on $O_2(^1\Delta)$ and $I^*(^2P_{1/2})$. Hence, the outlet of the generator usually has a cold trap to remove impurities such as H_2O and H_2O_2. Usually, dry ice is used in the cold trap.

There are four types of chemical generators commonly used to produce $O_2(^1\Delta)$: bubbler, atomizer, wet wall tube array and rotating disk. The bubbler is most mature and the rotating disk can be easily scaled up.

(1) Bubbler Generator

A bubbler generator is simple in structure and is widely used in small COIL experiments. Figure 2 is a schematic diagram of the device. Chlorine gas passes through a bubbler (glass tube with many drilled holes or porous sintered glass plate) to generate bubbles continuously in the H_2O_2-NaOH solution. A large amount of bubbles provides a high reaction contact surface area.

Because reaction (3) takes place at the gas/liquid interface by diffusion, the following is an expression for the percent of $O_2(^1\Delta)$ molecules that survive a distance d in the solution:

$$\eta = \sqrt{\frac{D}{d^2\alpha}}\left[1 - \exp\left(-\sqrt{\frac{d^2\alpha}{D}}\right)\right], \quad (4)$$

where D is the diffusion coefficient of O_2 in the solution, i.e., 5×10^{-6} cm^2/s, and α is the quenching rate of $O_2(^1\Delta)$,

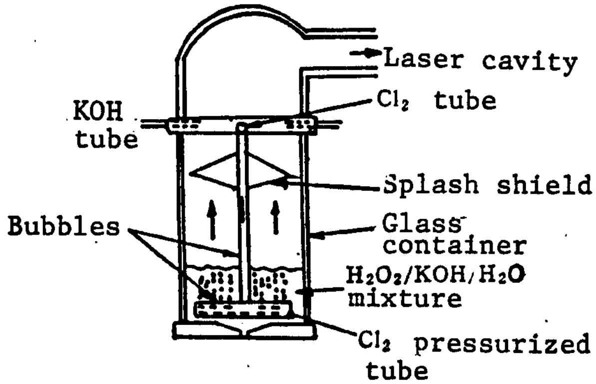

Figure 2. $O_2(^1\Delta)$ Bubbler Generator

which is 0.5×10^6/s in H_2O_2-NaOH. If 85 percent of the $O_2(^1\Delta)$ is supposed to survive, then from equation (4) the allowable diffusion distance in the solution is merely 10^{-6} cm. The reaction ought to take place in a 10^{-6}-cm-thick liquid film. If the chlorine partial pressure is too high, then it diffuses too deeply into the liquid film and the $O_2(^1\Delta)$ generated can escape from the liquid phase and is quenched back to ground-state O_2. From Table 1, it is apparent that quenching at the liquid-gas interface is most critical. The generator can only operate at low pressure. Usually, a bubbler generator operates at below 2-3 Torr.

Table 1. $O_2(^1\Delta)$ Lifetime in Various Media

Liquid phase	Gas phase		Wall collision
2×10^{-6} s	P (Torr)	τ(s)	10 s
	1.7	1	
	10	0.17	
	17	0.1	

(2) Disk Generator

As shown in Figure 3, a disk generator has many circular disks. When these disks rotate in a container filled with H_2O_2-NaOH, the disk wall is covered with a film of

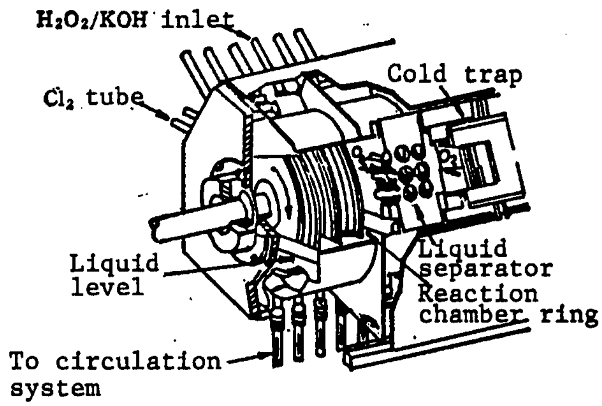

Figure 3. Schematic Diagram of Disk Generator

H_2O_2-NaOH which reacts with Cl_2 to produce $O_2(^1\Delta)$. The reactant liquid film reenters the solution as the disk rotates to get replenished. Reaction byproducts are also removed as well. Temperature control of the generator is accomplished by cycling the reactant liquid through a heat exchanger. The $O_2(^1\Delta)$ gas stream which contains liquid microparticles enters a cold trap at the outlet in order to reduce its water vapor content. This kind of generator can provide a large and stable reaction contact surface for the production of $O_2(^1\Delta)$ at a high rate. In addition, the partial pressure of $O_2(^1\Delta)$ produced is also relatively higher. The laser output is proportional to the partial pressure of $O_2(^1\Delta)$.

Based on reports, disk $O_2(^1\Delta)$ generators have been used in large COILs in other countries at a rate of 1 gram equivalent of $O_2(^1\Delta)$ per second. The total pressure is approximately 10-20 Torr and the concentration of $O_2(^1\Delta)$ is as high as 90 percent. The CW laser output power can reach 35 kW.

2. Generation of Iodine Atoms (Dissociation of I_2)

When I_2 is injected from a nozzle into the $O_2(^1\Delta)$ containing gas stream in the laser cavity, rapid mixing occurs. The following reaction takes place:

$$I_2(^1\Sigma) + O_2(^1\Delta) \longrightarrow I_2^* + O_2(^3\Sigma) \qquad (5)$$

$$I_2^* + O_2(^1\Delta) \longrightarrow 2I(^2P_{3/2}) + O_2(^3\Sigma) \qquad (6)$$

where I_2* is an excited iodine atom. The reactions described above quickly cause ground-state iodine molecules to dissociate into ground-state iodine atoms $[I(^2P_{3/2})]$. This dissociation reaction can be summarized as below:

$$nO_2(^1\Delta_g) + I_2(^1\Sigma_g^+) \longrightarrow nO_2(^3\Sigma_g^-) + 2I(^2P_{3/2}) \qquad (7)$$

where n is the number of $O_2(^1\Delta)$ molecules required. Experimentally, it was found that 2-5 $O_2(^1\Delta)$ molecules are required to dissociate a ground-state I_2 molecule into ground-state iodine atoms through collision. Because of the small I_2 to $O_2(^1\Delta)$ ratio, there is no substantial loss of excited oxygen molecules even though they are continuously used to pump I atoms.

3. Laser Gain

From equation (1), the energy of electronically excited meta-stable $O_2(^1\Delta)$ is transferred to ground state $I(^2P_{3/2})$ by way of resonance to produce excited iodine atoms $I^*(^2P_{1/2})$. The relevant energy levels are shown in Figure 4. The exotherm of reaction (1) is at 279 cm^{-1}. Iodine has a non-uniform gain spectrum. Only the highest gain transition generates a laser beam. This type of gain relation can be derived theoretically. Considering the fact that the upper and lower energy levels of iodine atom have a degeneracy g_u and g_l of 7 and 9, respectively, and particles in superfine levels are statistically distributed by weight, then the number of particles in the upper level is $N_u = (1/12)\, g_u\, [I^*]$ and that in the lower level is $N_l = (1/24)\, g_l\, [I]$. The spectrum width $\Delta\nu$ is the Doppler width. Then, the small-signal gain of the COIL can be expressed as

$$g_0 = \frac{A\lambda^3}{8\pi}\sqrt{\frac{m}{2\pi kT}}\cdot\frac{7}{12}\left([I^*]-\frac{1}{2}[I]\right) = \sigma\left([I^*]-\frac{1}{2}[I]\right), \qquad (8)$$

where A is the Einstein coefficient of spontaneous emission, λ the laser wavelength, and $[I^*]$ and $[I]$ are the concentrations of excited iodine atoms $I^*(^2P_{1/2})$ and ground-state iodine atoms $I(^2P_{3/2})$, respectively. The ambient-temperature excitation cross section, σ, is 5-7.4 x 10^{-18} cm^2. Because the forward and inverse reaction rates of the oxygen-iodine resonance reaction (1) are both fast, and taking k_1 and k_2 are the rate constants, when equilibrium is reached the small-signal gain can be expressed as follows:

$$g_0 = \sigma[I_0]\frac{\left(2K_{eq}\dfrac{F}{1-F+\Sigma\frac{k_M}{k_2}M_0}-1\right)}{\left(K_{eq}\dfrac{F}{1-F+\Sigma\frac{k_M}{k_2}M_0}+1\right)}, \qquad (9)$$

where $F = \dfrac{[O_2(^1\Delta)]}{[O_2(^1\Delta)]+[O_2(^3\Sigma)]}$, $K_{eq} = \dfrac{k_1}{k_2}$,

$$M_0 = \frac{[M]}{[O_2(^1\Delta)]+[O_2(^3\Sigma)]};$$

M_0 represents the ratio of excited-state $I^*(^2P_{1/2})$ quenching matter M to total oxygen, [M] is the quencher

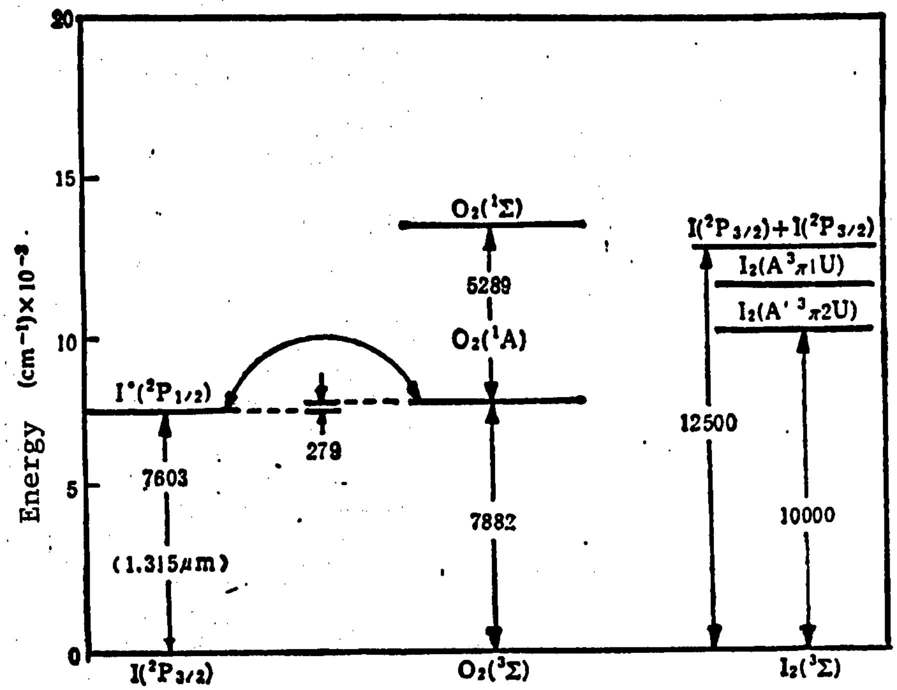

Figure 4. Energy-Level Diagram

concentration, and k_M is the quenching rate constant. $[O_2(^1\Delta)]$ and $[O_2(^3\Sigma)]$ are the concentrations of $O_2(^1\Delta)$ molecules and oxygen molecules, respectively. For a CW COIL, $[I_o]$ represents the initial iodine molecule concentration. From equation (9), we can see that the small-signal gain of a COIL is not only influenced by the initial iodine-molecule concentration but also by the percent of $O_2(^1\Delta)$ concentration relative to total oxygen concentration, F. Hence, the gain can be enhanced by improving the performance of the $O_2(^1\Delta)$ generator. Gains greater than 1 percent have been obtained. Furthermore, quencher concentration M_o and k_M also affect the gain. It is also possible to derive from equation (9) that the concentration percent of $O_2(^1\Delta)$ should not be less than 15 percent. Otherwise, population inversion of excited iodine atoms would not occur and it will not lase. This is known as the threshold concentration percent for $O_2(^1\Delta)$.

II. Potential Applications of the COIL

Since their advent, lasers have been used in a variety of applications such as materials processing, optical communication, metrology and medicine. The most widely used lasers are the CO_2 laser and YAG laser. The CO_2 laser is a mid-infrared laser; although it is widely used in metal cutting and welding because of its high efficiency and high power, it is not ideal for metal processing due to its long wavelength. Furthermore, it is not suited for use with optical fibers. YAG laser light may be transmitted in silicon optical fiber at a low loss. The YAG laser, with a wide range of applications, is however not as powerful and the beam quality is not as good. People are searching for a laser which has a high output power, can be transmitted in optical fiber at a low loss, and has excellent beam quality for industrial applications. The wavelength of a COIL is 1.315 μm and its output power is higher than that of a CO_2 laser. From Figure 5,[3] this wavelength happens to be the lowest transmission-loss band of the silicon fiber. The COIL is a gas laser which is capable of delivering a high quality beam compared to a YAG laser. Hence, it has the potential to become a new industrial laser, following the CO_2 and YAG lasers. A 1-kW COIL has been developed in Japan and will be used in industry. By way of optical fiber transmission, it is capable of operations such as metal cutting, welding, drilling and thermal treatment three-dimensionally in all orientations.

In addition to industrial use, the COIL may also have medical applications such as treatment of tumors. Furthermore, since high-energy lasers can transmit destructive energy to distant targets in the form of a beam, it also has the potential of becoming a directed energy weapon. A high-power COIL may also have other military applications.

Despite numerous advantages, there are some problems to solve before the COIL can be used in the field. The key is to ensure that the laser can operate steadily at high efficiency and continuously over long periods of time. The designers are addressing these issues at the present

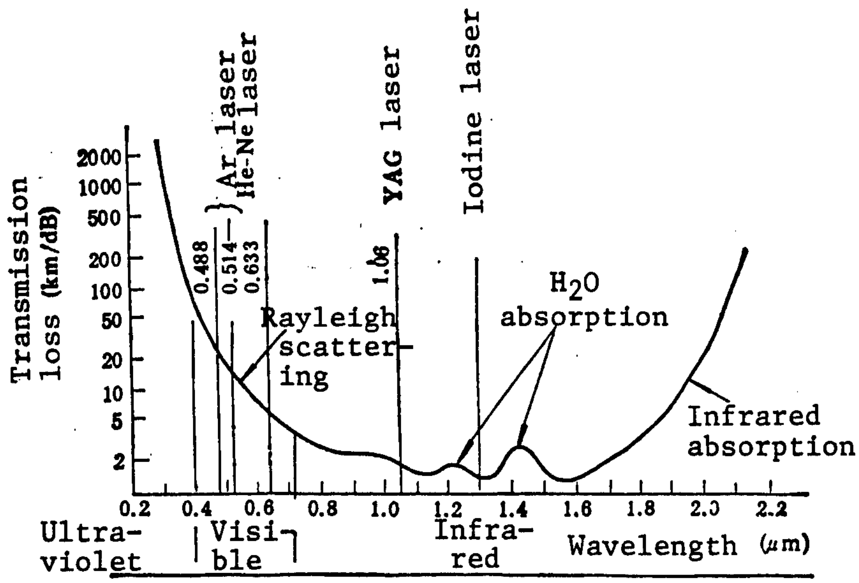

Figure 5. Transmission Characteristics of Silicon Fiber

moment. It is expected that COILs will be used in industrial and medical applications in the near future.

III. COIL Research at the CAS Dalian Institute of Chemistry and Physics

COIL research at DICP began in the early 80's. A small CW COIL and a pulse COIL triggered by photo-dissociation and electrical discharge have been developed to date. In addition, some progress has been made in laser devices, theory and model computation, and performance testing and diagnostics. A number of technical people have been trained. This has made a significant contribution to promoting chemical laser research in China.

1. Laser Research

In the early 80's, DICP developed the first 10 W CW COIL in China. Its chemical efficiency is comparable to that of similar devices developed abroad. Since then, because of its unique feature, the pulse COIL has attracted more attention. While CW COIL research is relatively mature, pulse COIL research is very complex and not much progress has been made to date. DICP began to investigate pulse COILs as early as 1983. In 1984, this institute led the world in obtaining a pulse COIL by way of photo-dissociation. Furthermore, iodide was used instead of iodine to realize pulse operation. This solved the problem of the strong quenching effect of iodine molecules on $I^*(^2P_{1/2})$, which adversely affected laser output. This work created a new path for the high-power pulse COIL. Since the Seventh 5-Year Plan, DICP has made further improvements on the laser. A new concept was introduced to use low-energy electrons to trigger the COIL reaction, instead of photo-dissociation. Experimentally, DICP has successfully solved the problem wherein iodide could not be selectively dissociated by means of electron collision. DICP proved that low-energy electron triggering is more effective than photo-dissociation and developed the first electrically discharged pulse COIL in the world. A synchronized two-step discharge technique was employed to enhance the energy extraction efficiency from low-gain excitation media. Major breakthroughs were made in terms of performance and efficiency compared to triggering by photo-dissociation. The output energy was raised from 160 mJ per pulse to 450 mJ per pulse, chemical efficiency from 10 or 12 percent to 34 percent, and electrical triggering efficiency from 0.016 percent to 18 percent (approximately 1,100 times higher); the intrinsic electrical efficiency is 144 percent. DICP has also overcome problems associated with light triggering, such as low electrical efficiency and difficulty in repetitive pulsing. The trigger device has become much more compact. To date, the only pulse COIL available outside China is triggered by photo-dissociation; it only has a chemical efficiency of 15 percent and electrical efficiency of 0.67 percent. These accomplishments have attracted a great deal of interest. For this work, DICP received a first-class technical progress award from the CAS in 1989.

2. Theory and Model Computation

Any device design requires theoretical guidance. In the past decade, DICP has educated and trained a large number of people in theory and model computation to provide a solid foundation for theoretical guidance of experimental work. Let us use the study of the light-triggered COIL as an example: theoreticians were asked to carry out mathematical modeling before device design work began. The model includes 35 chemical kinetic processes. Iodine atoms were produced by way of flash photolysis of iodide, RI, and then pulse COIL output was obtained through energy transfer from $O_2(^1\Delta)$. The model was solved on a computer using the Runge-Kutta-Gill integral. It was found that this type of photo-dissociation-triggered pulse COIL could utilize up to 60 percent of the chemical energy supplied by $O_2(^1\Delta)$. Under certain operating conditions, it is possible to obtain a 10-150-µs-wide pulse.

In 1984, DICP experimentally confirmed the concept using the $O_2(^1\Delta)$-CF_3I-Ar system and obtained pulse COIL output triggered by photo-dissociation for the first time. The pulse width is tunable in the range of 10-130 µs by varying the cavity pressure, which is consistent with theoretical computation.

3. Diagnostic Technique

A method to measure the absolute concentration of $O_2(^1\Delta)$ using infrared calorimetry, a low-signal gain coefficient measurement technique, a device to determine the quality of laser beam at 1.315 µm, and a method to measure trace water and chlorine content at low pressure were established. Let us take the low-signal gain diagnostic test as an example. Because the COIL is a low-gain device, it is important but difficult to measure its gain coefficient. DICP developed a near-diffraction-limit photo-dissociation triggered pulse iodine laser to produce the probing light (energy output 40-50 mJ) for measuring the gain. Difficulties such as synchronous identification, laser-wave vibration and multiple-pass loss were overcome to obtain a gain coefficient of 2×10^{-3} cm^{-1}, the first piece of measured data worldwide for this research.

In conclusion, after years of hard work, China is leading the rest of the world in COIL research.

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Radar Cross-Section Analysis of Dipole-Array Antennas

40100033B Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 14 No 5, Sep 92 pp 496-501

[English abstract of article by Deng Shuhui and Ruan Yingzheng of the University of Electronic Science and Technology of China, Chengdu 610054; MS received 13 Oct 90, revised 14 Nov 91]

[Text] A study of the back scattering from a planar or cylindrical array of loaded dipoles is presented. The current distribution on the dipoles and the radar cross section (RCS) of the array in consideration of the interaction among dipoles are obtained by the moment method. Theoretical results are compared with the measured ones, and good agreement is achieved. The loading array technique and the curved surface array technique would greatly reduce the RCS of an array, which would be valuable for engineering applications.

Motion Compensation for ISAR Imaging Using Scattering Centroid

40100033D Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 14 No 5, Sep 92 pp 532-536

[English abstract of article by Mao Yinfang, Wu Yirong, Zhang Yongjun, and Chen Zongzhi of the Institute of Electronics, CAS, Beijing 100080; MS received 22 Aug 91, revised 23 Mar 92]

[Text] Motion compensation for ISAR [inverse synthetic aperture radar] imaging using scattering centroid (called reference centroid method) is proposed and studied. The internal relations and differences between correlation method and the new method are analyzed. The noise effect on the motion compensation is discussed. To solve the problem, a new method which uses echo goodness-of-fit curve to smooth the centroid range trace and phase trace is proposed. The reference centroid method is used to process simulated and real ISAR data of moving target, and satisfying motion compensation results are obtained. The results show that the method is correct and effective.

The ML Bearing Estimation by Use of Neural Networks

40100033A Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 14 No 5, Sep 92 pp 449-456

[English abstract of article by Luo Falong of Qinghua University, Beijing 100084; MS received 9 Sep 91, revised 23 Mar 92]

[Text] A neural network to implement the maximum likelihood (ML) bearing estimation algorithm in real time is proposed. Both analysis and simulation show that

this neural network is guaranteed to be stable and to provide the ML bearing estimation within an elapsed time of only a few characteristic time constants of the network. As a result, this proposed neural network is satisfactory for real-time bearing estimation.

Study on Pt-GaAs Schottky Barrier APD

40100033C Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 14 No 5, Sep 92 pp 517-522

[English abstract of article by Guo Kangjin, Hu Weiyang, Yao Wenlan, and Chen Lianyong of the Shanghai Institute of Metallurgy, CAS, Shanghai 200233; MS received 16 Jun 91, revised 26 Nov 91]

[Text] Pt-GaAs Schottky barrier APDs have been investigated. The devices were fabricated on GaAs epitaxial layer with carrier concentration of 0.5-3 x 10^{15} cm^{-3} and thickness of about 20 μm. Guard ring along with sensitive area was formed by H^+ bombardment with energy of 500 keV and dosage of 1 x 10^{15} cm^{-2} to prevent edge breakdown. Semi-transparent Pt film was evaporated using a special evaporation source. The peak response wavelength of the device is 8600-8835 Angstroms at different bias voltages. Optical absorption edge could extend to 9700 Angstroms. Franz-Keldysh effect has been observed. A multiplication factor of above 100 can be reached. Dark current is about several nA. Excess noise coefficient is 7 and both rise and fall time were less than 1 ns. The device can be integrated monolithically and planarly with GaAs FET.

Frequency Doubling of Tunable Ti:Sapphire Laser in β-BaB_2O_4

40100032A Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 19 No 9, Sep 92 pp 641-644

[English abstract of article by Wu Chengjiu, Wei Li, Zhou Dongfang, Zhao Meirong, and Tang Honggao of Anhui Institute of Optics and Fine Mechanics, CAS, Hefei; MS received 27 Aug 90, revised 9 Nov 90]

[Text] The phase-match angles of type I in BBO are 36.0-21.2° for Ti:Al_2O_3 tuning range of 660-1200 nm. UV output energy of SHG of a tunable Ti:Al_2O_3 laser of above 1.4 mJ/pulse and conversion efficiency of 26.2 percent have been obtained. An analysis shows that higher output energy and conversion efficiency are possible and BBO is better than KDP and $LiIO_3$ for frequency doubling.

Ultrafast Optoelectronic Switching in Circular Pulse Generator

40100032B Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 19 No 9, Sep 92 pp 659-662

[English abstract of article by Gu Guanqing, Chen Lanrong, Zhi Tingting, and Fn Dianyuan of Shanghai Institute of Optics and Fine Mechanics, CAS, Shanghai; MS received 29 May 91, revised 26 Aug 91]

[Text] A novel ultrafast electronic pulse generator system consisting of a voltage charged transmission line (VCTL) and an intrinsic silicon optoelectronic switch has been successfully developed. The switch in the circular circuit is illuminated by a laser pulse at 1.06 micrometers wavelength and 80 picoseconds width. A nanosecond square-wave electronic pulse with an ultrafast risetime and falltime (less than 200 ps) and a width determined by the length of the transmission line and switching efficiency limited by the load has been obtained.

Optical Logic Operations Using Matrix Liquid Crystal Modulators

40100032C Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 19 No 9, Sep 92 pp 706-711

[English abstract of article by Feng Dazeng, Xia Shaofeng, Zhao Huanqing, and Zhang Zhiming of the Physics Department, Fudan University, Shanghai 200433; MS received 3 Dec 90, revised 4 Mar 91]

[Text] In this paper, matrix liquid crystal modulators are produced using matrix addressing technique, which can display images controlled by IBM/XT computer. Using the modulators, a new optical logic operation unit is set up; 16 Boolean logic operations and optical half adder are performed by the unit. This compact, polarization-encoded optical logic unit is a basic element to realize optical computing.

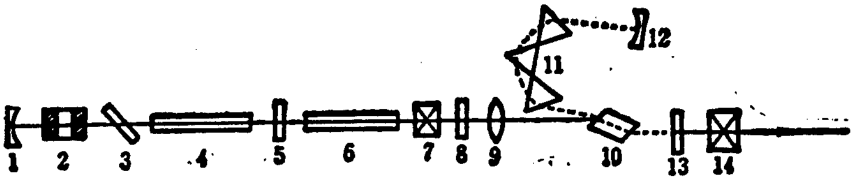

Figure 1. Schematic of Experimental Setup for SHG of Ti:Al_2O_3 Laser in β-BaB_2O_4

1-6. Q-switched Nd:YAG oscillator-amplifier system; 7. SHG crystal KTP; 8. dichroic; 9. lens; 10. Ti:Al_2O_3 laser rod; 11. prism; 12. HR mirror; 13. output mirror; 14. SHG crystal BBO

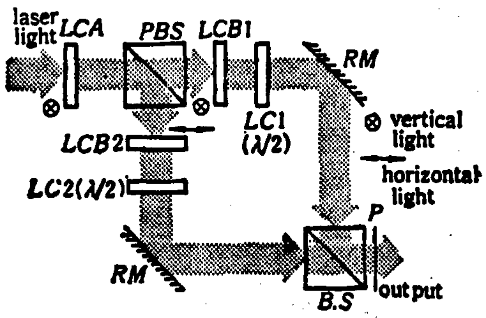

Figure 1. Optical Logic Operation System

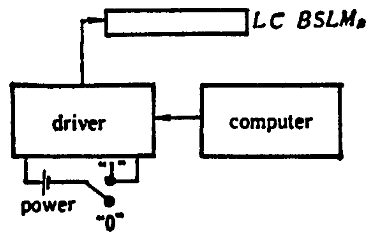

Figure 2. States of Modulators

Table 1. Logic Operations Corresponding to the States of Modulators

States of modulators				Logic operations
LCB1	LCB2	LC1(λ/2)	LC2(λ/2)	
0	0	0	0	A
0	0	0	1	1
0	0	1	0	0
0	0	1	1	$\bar{A}$
0	1	0	0	A OR. B
0	1	0	1	A OR. $\bar{B}$
0	1	1	0	$\bar{A}$. AND. $\bar{B}$
0	1	1	1	A. NOR. B
1	0	0	0	A. AND. $\bar{B}$
1	0	0	1	A. NAND. B
1	0	1	0	A. AND. B
1	0	1	1	$\bar{A}$. OR. B
1	1	0	0	A. XOR B
1	1	0	1	$\bar{B}$
1	1	1	0	B
1	1	1	1	A. EQV. B

Table 2. Truth Table of Half Adder

A = 0, B = 0	A = 0, B = 1	A = 1, B = 0	A = 1, B = 1	Logic
0	0	1	1	A
1	1	1	1	1
0	0	0	0	0
1	1	0	0	$\bar{A}$
0	1	1	1	A. OR. B
1	0	1	1	A. OR. $\bar{B}$.
0	1	0	0	$\bar{A}$. AND. B
1	0	0	0	A. NOR. B
0	0	1	0	A. AND. $\bar{B}$
1	1	1	0	A. NAND. B
0	0	0	1	A. AND. B
1	1	0	1	$\bar{A}$. OR. B

Table 2. Truth Table of Half Adder (Continued)

0	1	1	0	A. XOR. B
1	0	1	0	$\bar{B}$
0	1	0	1	B
1	0	0	1	A. EQV B

Table 3. Truth Table of Boolean Logic

A	B	Carry C = A. AND. B	Sum S = A. XOR. B
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

Gain-Switching Dynamics of LDA End-Pumped Nd:YAG Lasers

40100037A Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 12 No 9, Sep 92 pp 784-789

[English abstract of article by Li Zhenhua, Fan Qikang, and Qiu Wenfa of the Department of Optical Engineering, Zhejiang University, Hangzhou 310027, and Zhou Fuzheng of the Shanghai Institute of Optics and Fine Mechanics, CAS, Shanghai 201800; MS received 13 Sep 91, revised 11 Nov 91]

[Text] Gain-switching dynamics of laser diode array (LDA) end-pumped Nd:YAG lasers were studied in detail by means of mathematical calculation of the rate equations. Pulsed laser output at 1.064 μm wavelength with peak power of nearly 200 mW and pulse width less than 200 ns has been obtained by gain switching of a LDA (λ_p = 0.808 μm) end-pumped Nd:YAG laser. The experimental results are in agreement with those of theoretical calculations.

Study of Band-Filling Effect in Quantum Well With Excitation of 532 nm Picosecond Laser

40100037B Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 12 No 9, Sep 92 pp 790-795

[English abstract of article by Qian Shixiong and Li Yufen of the Physics Department, Fudan University, Shanghai 200438, Peng Wenji, Li Chinxin, and Yu Zhenxin of the Institute of Laser Spectroscopy, Zhongshan University, Guangzhou 510275; MS received 10 Sep 91]

[Text] By using a mode-locked picosecond pulse laser at 532 nm and a time-resolved detection system, we have measured the time-resolved photoluminescence (PL) spectra of $In_xGa_{1-x}As/GaAs$ single-quantum-well samples at 77K with different excitation powers. At low excitation, the PL peak of InGaAs well shows small shift with time. But at 175 mW excitation, there is a great blue shift of the PL peak at the beginning and shift back to the longer wavelength side with time. The result clearly shows the band-filling effect of the carriers existing in the well.

Wedge-Ring-Shaped Detector Synthesized With Computer-Generated Hologram, Its Application in Pattern Recognition

40100037C Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 12 No 9, Sep 92 pp 803-808

[English abstract of article by Liu Liren and Wang Tianji of Guangzhou Institute of Electronic Technology, CAS, Guangzhou 510070; MS received 19 Aug 91, revised 11 Nov 91]

[Text] The CGH/WRD system (computer-generated hologram/wedge-ring-shaped detector) were synthesized with CGH and CCD devices. It allows separation of the detector shape function from the detection function. The use of CGH provides considerable flexibility in the detection process. The design considerations are presented in detail with some experimental results on pattern recognition.

Calculation of Heterojunction Conduction Band for Field-Assisted InP/InGaAsP/InP Semiconductor Photocathodes

40100037D Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 12 No 9, Sep 92 pp 830-834

[English abstract of article by Li Jinmin, Guo Lihui, Zhang Gongli, Wang Cunrang, and Hou Xun of Xi'an Institute of Optics and Precision Mechanics, CAS, Xi'an 710068; MS received 16 Sep 91, revised 4 Nov 91]

[Text] By using the hyperbolic grading function and taking account of the potential variance near the surface of photocathodes caused by an applied bias, the conduction-band structures at the heterojunction interface for a field-assisted InP/InGaAsP/InP semiconductor photocathode are analyzed and calculated. The profile curves of conduction-band structure at the heterojunction interface with the different parameters of materials have been obtained. In order to achieve perfect transmission efficiency at heterojunction, the calculation results have shown the conditions for the thickness and the doping concentration of the emission layer, the doping concentration of the absorption layer, as well as the grading width at the heterojunction interface and the applied

bias. The results are helpful in designing field-assisted semiconductor photocathodes and choosing material parameters.

Two-Dimension-Multiplexing Optical Fiber Displacement Sensor Using Frequency-Modulated Laser Diode

40100037E Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 12 No 9, Sep 92 pp 835-840

[English abstract of article by Zheng Gang, Tian Qian, and Liang Jinwen of the Precision Instruments Department, Qinghua University, Beijing 100084; MS received 29 Oct 90, revised 3 Oct 91]

[Text] Based on the principles of laser-diode linear frequency modulation heterodyne interference and frequency division multiplexing, the multiplexing technique of an optical fiber displacement sensor is studied. A two-dimension-multiplexing optical fiber displacement sensor is designed and fabricated. The problem of cross-talk of signals is studied. The experiment proves that the cross-talk error of the sensor is smaller than 0.02 μm and the measurement accuracy of each channel is 0.05 μm.

Geometric Correction Model for Remotely Sensed Satellite Images

40100034A Wuhan HUAZHONG LIGONG DAXUE XUEBAO [JOURNAL OF CENTRAL CHINA UNIVERSITY OF SCIENCE AND TECHNOLOGY] in Chinese Vol 20 No 5, Oct 92 pp 135-140

[English abstract of article by Liu Jian, Jiang Ying, Peng Fuyuan, and Wen Hao; MS received 27 Jan 92]

[Text] A method for geometrically correcting remotely sensed satellite images is described. A simple and practical dynamic photographic model based on the geometric theory of satellite imaging is worked out and the model parameters are piecewise optimized. The original image is coarsely sampled and then the optimized model is used to geometrically correct the image on each sample point. In this way, a "fictitious control-point network" is found. In order to quicken the correction speed, quasi-linear transformation is used in the network to interpolate in space. Grey re-sampling is then used to complete the geometric correction and output the image that has been corrected geometrically. By this method, fewer ground control-points are needed and good geometric correction accuracy and high speed can be achieved. Experimental results are satisfactory. The method proposed is suitable for geometric correction of satellite images with serious geometric distortion and large scanning angle.

On an Intelligent Telemetry System Based on Linear Array CCD

40100034B Wuhan HUAZHONG LIGONG DAXUE XUEBAO [JOURNAL OF CENTRAL CHINA UNIVERSITY OF SCIENCE AND TECHNOLOGY] in Chinese Vol 20 No 5, Oct 92 pp 141-146

[English abstract of article by Chen Jun, Ye Hunian, Yang Xinli, and Chen Zhengrong; MS received 27 Jan 92]

[Text] An intelligent telemetry system using linear array CCD is presented. It is proposed that envelope signals formed by the CCD output pulse series wave serve as the feature of the photogrammetry target. A comparison of the results of a Fourier frequency-spectrum analysis for CCD output envelope curves such as the sine wave, Gaussian wave, rectangular wave and pulse wave makes it possible to conclude that after this kind of method is used in telemetry application in the case of non-image display, the sampling frequency to the envelope signals will be lower, the efficiency will be improved and the resource extravagance will be cut down. By combining computer processing techniques with pattern recognition methods, the extraction, analysis, judgement and recognition of the target features are possible with a smaller amount of data.

Institute 45 Develops 0.8-1.0-Micron Direct Stepper Exposure Machine

93P60065A Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 19 Oct 92 p 3

[Article by Shang Ming [1424 2494]: "MMEI Institute 45's Scientific Research Produces 'Double Bumper Harvest'"]

[Summary] MMEI's Institute 45, a national leader in the development of semiconductor and optical microfine processing equipment, has recently reaped a "double bumper harvest" with its perfection of two new apparatuses: the first is a 0.8-1.0-μm direct stepper exposure machine—a key apparatus for fabrication of VLSI circuits and one that has been COCOM-controlled—meeting mid-to-late-80s international standards, and the second is a fully automated probe testing station, both key Eighth 5-Year Plan projects.

Qinghua Microelectronics Institute Develops Micro Electrostatic Motor

93P60065B Beijing ZHONGGUO KEXUE BAO [CHINESE SCIENCE NEWS] in Chinese 20 Oct 92 p 1

[Article by Li Li [2621 5461]: "Qinghua Microelectronics Institute Develops Micro Electrostatic Motor"]

[Summary] Scientists at the Qinghua University Microelectronics Institute (QUMI) have recently developed a micro electrostatic motor with a rotor diameter of only 100 microns. This micromachine rotates at a speed as high as several 10,000 rpm—the highest value reported to date worldwide for such a micromachine. The micro electrostatic motor, developed by a research team led by noted microelectronics specialist and [CAS] Academic Committee member Prof. Li Zhijian [2621 1807 1017], has the unique feature that the motor and rotation speed sensor are integrated in one device. The field of micromachines has been a "hot topic" of international competition in recent years, and Chinese authorities have included micromachine research in the Eighth 5-Year Plan. The QUMI researchers have previously developed various microstructure sensors, micro electrostatic switches, and microturbines, and this newest development has propelled China into the world's front ranks in micromachine R&D.

Miniature Package Monolithic IC Production Line Operational

93P60065C Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 23 Oct 92 p 1

[Article by Song Rushan [1345 1172 1472] and Chen Dashou [7115 1129 1108]: "Micro Package Integrated Circuit Projects in Gansu Completed"]

[Summary] A late-80s-international-level miniature package monolithic IC/thick-film IC production line, combining advanced equipment imported from the United States with domestically made equipment, was formally completed and put into production on 14 October at State-run Plant 749 in Gansu Province. Post-processing yield for this line is over 98 percent. Annual production capacity of the line is 5 million DIP [dual in-line package] ICs, 10 million SOP [expansion unknown] ICs, and 1 million standard thick-film ICs, with all exterior technical indicators for the DIPICs meeting IEC (International Electrotechnical Commission) standards and exterior technical indicators for the SOPICs meeting standards of the U.S. firm Motorola. The new production line will annually account for 38 million yuan in gross industrial output value, 25 million yuan in revenue, 2.5 million yuan in profits, and over US$3 million in foreign exchange earned.

Raman Scattering Study of CdTe/GaAs Heterostructures Grown by Metalorganic Chemical Vapor Deposition

40100030A Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 13 No 10, Oct 92 pp 589-594

[English abstract of article by Lao Pudong, Guo Yile, and Zhang Xiaofeng of the Department of Physics, Fudan University, Shanghai, 200433, Yao Wenhua of the Center of Analysis and Measurement, Fudan University, Shanghai, 200433, Xu Fei and Ding Yongqing of the Shanghai Institute of Metallurgy, CAS, Shanghai, 200050; MS received 27 Jul 91, revised 4 Nov 91]

[Text] Raman scattering from CdTe film epitaxially grown on GaAs(100) substrates is reported, and a method to determine the strain in epitaxial layer using both the width and position of LO phonon Raman peak is presented. The results show that in CdTe films with thickness up to about 2.5 μm there is still strain, and that the magnitude of strain depends on growth conditions. From the analysis of Raman spectra meaningful information about the film quality is extracted, supported by X-ray double-crystal diffraction as well as scanning electron microscopy experiments.

Quantification of Zinc-Implanted GaAs by SIMS

40100030B Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 13 No 10, Oct 92 pp 600-606

[English abstract of article by Chen Yu and Fan Chuizhen of Lanzhou Institute of Physics, Lanzhou, 730000; MS received 2 Nov 90, revised 21 Mar 92]

[Text] Zinc-ion-implanted GaAs is analysed quantitatively by SIMS [secondary ion mass spectroscopy] using implanting dose method. A stable and reliable Relative Sensitivity Factor (RSF) of zinc in GaAs is obtained. To quantify the same kind of sample by RSF method, a satisfactory result is obtained with deviation less than 8

percent. Besides, the influence of oxygen on secondary ion yield of impurity in GaAs has been studied. A modified quantitative method which quantifies the zinc-implanted GaAs under chamber oxygen flooding is proposed.

InAsPSb/InAs Mid-Infrared Photodetectors

40100030C Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 13 No 10, Oct 92 pp 623-628

[English abstract of article by Zhang Yonggang, Zhou Ping, Shan Hongkun, and Pan Huizhen of Microelectronics Branch, Shanghai Institute of Metallurgy, CAS, Shanghai, 200233; MS received 13 Jul 91, revised 1 Nov 91]

[Text] The fabrication and characterization of epitaxial InAsPSb/InAs mid-infrared (1-3.2 μm) photodetectors optimised for room-temperature operation at the low-loss-wavelength window of fluoride fibre is reported. Detectivity of 4 x 10^9 cm-$Hz^{1/2}$/W at 2.6 μm and transient response time of 1.2 nS (FWHM) at zero bias have been achieved at room temperature on the photodetectors with PIN mesa structure.

Nation's First HTS Far-Infrared Detector Developed

93P60079A Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 44, 11 Nov 92 p 11

[Article by Lin Li [2651 4409]: "New Superconducting Far-Infrared Detector Unveiled in Nanjing"]

[Summary] The nation's first high-temperature superconducting (HTS) far-infrared detector was recently developed by the Zhong Shan Group's Nanjing Institute 55 via the institute's independently manufactured high-quality superconducting thin films, indicating this aspect of HTS research has entered a utilitarian phase. HTS far-infrared (detection range of 20 μm to 1,000 μm) detectors are used in space technologies, nuclear technologies, medical research, industrial fault testing, and national defense. The intelligent detector developed by Institute 55 is a 1 x 8 linear array with a measured detectivity and equivalent noise power meeting the current international state-of-the-art.

Shanghai Institute's YBCO HTS With Record Jc Passes Appraisal

93P60066A Shanghai WEN HUI BAO in Chinese 7 Nov 92 p 1

[Article by Qian Weihua [6929 4850 5478]: "Major New Advance for Shanghai's High Temperature Superconducting Materials Research"]

[Summary] New yttrium-barium-copper oxide high temperature superconductor (YBCO HTS) materials research of the CAS Shanghai Institute of Metallurgy (SIM) yesterday passed the expert appraisal jointly conducted by the State Superconductivity Research Center, CAS, and the Shanghai Municipal S&T Commission. These YBCO HTS materials, grown via SIM's "molten method," have undergone successive testing at Fudan University, the State Superconductivity Laboratory, and the U.S. National Magnetics Laboratory at magnetic field strengths of 80,000-200,000 gauss. These tests revealed that at liquid-nitrogen temperature (77.3K, or 196°C), the materials allowed a transmitted maximum current density of 20,000 amperes [per square cm], the highest critical current density (Jc) value attained to date worldwide for [such an] HTS material. It is understood that these materials will have important applications in areas such as the superconducting magnetic levitation train now being researched domestically. Also passing appraisal at the same time as SIM's HTS material was the liquid-helium temperature (4K, or 270°C) 120,000-gauss strong-magnetic-field superconducting magnet material developed by the China National Nuclear Corporation's Southwest Institute of Physics.

Silicon Bipolar Transistors With Poly Emitter for 77K Operation

93FE0047A Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 20 No 8, Aug 92 pp 23-28

[Article by Zheng Jiang [6774 3068], Wang Shu [3769 2562], Wang Yan [3769 3601], Wu Jin [0702 6855], Wei Tongli [7614 0681 4539], and Tong Qinyi [4547 0530 5030] of the Microelectronics Center, Southeast University, Nanjing 210018: "Silicon Bipolar Transistors With Poly Emitter for 77K Operation," supported by the National Natural Science Foundation; MS received May 91, revised Feb 92]

[Excerpts] **Abstract**

A poly emitter silicon bipolar transistor suitable for 77K operation is presented. Temperature models of current gain at different injection levels are given. The results indicate that current gain falls more rapidly as temperature drops at lower current levels. In addition, the effect of trapping of shallow level dopants on the cutoff frequency is discussed.

I. Introduction

A great deal of progress has been made in low-temperature microelectronics. Nevertheless, the performance of conventional silicon transistors is severely affected at liquid-nitrogen temperature.[1,2] The primary mechanisms for the deterioration are caused by bandgap narrowing due to heavy doping of the emitter and the trapping effect of shallow level dopants. In order to obtain bipolar silicon transistors suitable for 77K operation, many studies have been conducted worldwide.[3-5] In this paper, the development of a poly emitter silicon bipolar npn transistor suitable for 77K operation is described. It exhibits excellent electrical behavior at 77K. Furthermore, the theory and design of related devices are also presented.

II. Device Structure

Figure 1 shows the longitudinal cross section of a poly emitter bipolar silicon transistor. The donor concentration was determined by Hall effect measurement to be 1 x 10^{19} cm^{-3}, and its mobility is 40 cm^2/V-s. The polycrystalline silicon thin film is approximately 350 nm thick. The base is formed by boron ion implantation and the maximum boron concentration is 8 x 10^{18} cm^{-3}. The base is approximately 500 nm wide. Therefore, the base concentration is much higher than that in a conventional transistor, which results in a higher base breakdown and a lower base resistance. [passage omitted]

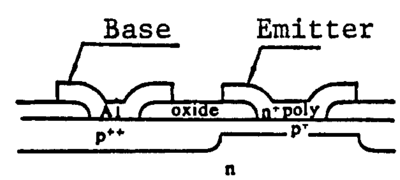

Figure 1

IV. Electrical Parameters of the Device

One of the important parameters of a low-temperature bipolar transistor is its base sheet resistance R_{dB}. R_{dB} is a function of hole mobility $\mu_{pB}(x)$ and base width W_B, and can be expressed as follows:

$$R_{dB}=\left\{\int_0^{W_B} q\mu_{pB}(x)p(x)\mathrm{d}x\right\}^{-1} \quad (21)$$

The above equation can also be written as

$$R_{dB}(T)=\{q\bar{\mu}_{pB}(T)G_B(T)\}^{-1} \quad (22)$$

where $\bar{\mu}_{pB}(T)$ is the mean hole mobility in the base region and G_B is the Gummel number of the base.

Figure 4 shows the relation between base sheet resistance R_{dB} and temperature at two dopant levels. It is shown that at above ambient temperature, R_{dB} increases with rising temperature due to phonon scattering. At low temperature, due to a carrier precipitation effect, R_{dB} rises exponentially as temperature falls. In addition, at low temperature, R_{dB} also increases with decreasing N_B.

The base Gummel number, G_B, for a high-performance bipolar transistor should be optimized. There are two major determining factors for G_B, i.e., (1) high current gain and (2) high breakdown voltage and low base resistance. Obviously, at low temperature it is possible to achieve high current gain and high breakdown voltage and lower base resistance by raising N_B. In other words, these two factors are consistent with each other at low temperature. This is quite opposite at ambient temperature.

In order to have a high cutoff frequency, it is necessary to reduce the compensating dopant level in the base region. As shown in Figure 2 [not reproduced], N_D must be below 10^{15} cm^{-3} to make n_c/n_t approach 1. This means that the dopant level of the n-type substrate must be less than 10^{15} cm^{-3}. Figure 5 shows the effect of substrate doping upon f_T at 77K. The substrate dopant concentration of the emitter region of the polycrystalline silicon transistor is chosen to be around 5×10^{14} cm^{-3}.

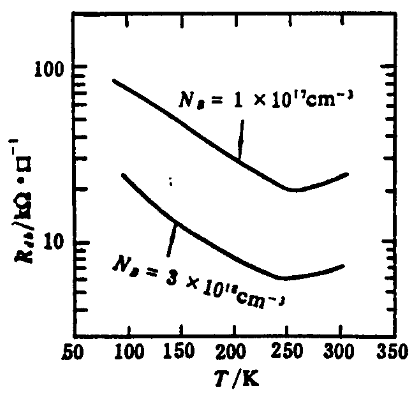

Figure 4

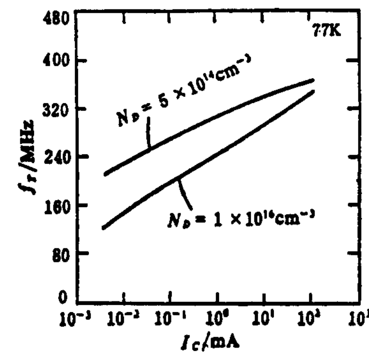

Figure 5

As discussed earlier, H_{FE} rises as N_E falls at 77K. Hence, in order to reach a high H_{FE} value at 77K, emitters cannot be doped too heavily. Furthermore, donor dopant in the emitter region cannot completely be ionized at low temperature. In order not to be affected by the precipitation effect, N_E must be greater than 3.5×10^{18} cm^{-3}.

Figure 6 shows the experimental I_c and I_B versus V_{BE} curves of the poly emitter transistor at 77K for $N_E = 1 \times 10^{19}$ cm^{-3} and $G_B = 1.5 \times 10^{14}$ cm^{-2}. Figure 7 shows the experimental curve of H_{FE} versus I_c at 300K and 77K. From the figure it is obvious that the H_{FE} of the device is suitable for use at 77K. Furthermore, H_{FE} has a relatively large positive temperature coefficient at low injection current levels.

In a conventional transistor, the BC junction is backward biased. This reverse bias causes the carriers injected from the emitter to create an electron-hole pair by means of collision ionization in the depletion region of the BC junction.[21] Let us use an npn transistor as an example (see Figure 8). The direction of the electric field is shown in the diagram. Electrons generated are swept toward the collector to become the collector output current. At the same time, holes will return to the neutral base region. The hole current that flows across the EB junction will be fixed by the emitter junction voltage. The remaining hole current becomes reverse base current. Hence, H_{FE} increases with rising V_{BC}. The avalanche multiple factor ξ may be obtained from the I-V curve as follows:

$$\xi = \Delta I_B/(I_c - \Delta I_B) \quad (23)$$

In conventional bipolar transistors, the collectors are usually lightly doped. Hence, the avalanche effect can normally be neglected at ambient temperature. However, as shown in Figure 9, the factor ξ increases significantly as temperature falls. Therefore, at low temperature the avalanche effect of the collector junction on H_{FE} must be taken into consideration. Figure 10 shows the experimental H_{FE} versus V_{BC} curves at 300K and 77K.

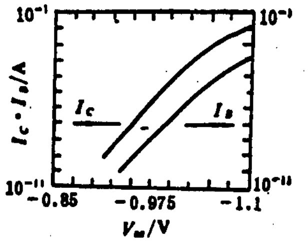

Figure 6

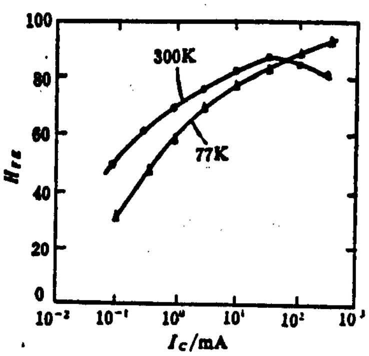

Figure 7

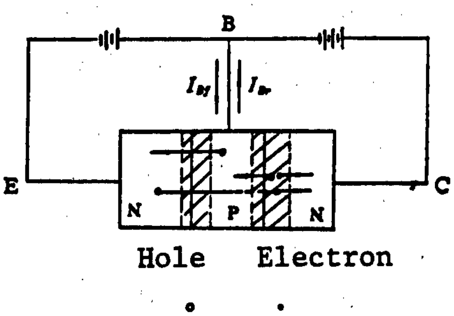

Figure 8

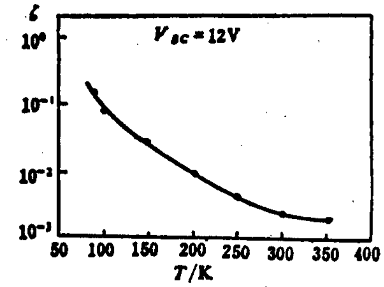

Figure 9

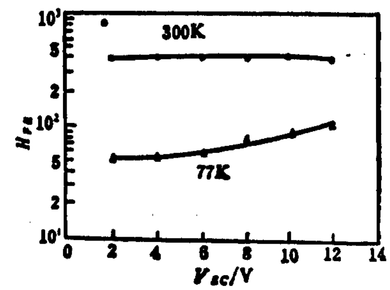

Figure 10

The figure shows that H_{FE} is independent of V_{BC} at ambient temperature. At 77K, however, H_{FE} increases as V_{BC} rises.

V. Conclusion

In the investigation of the 77K poly emitter silicon transistor, a temperature model for current gain is given. The trapping effect of shallow level impurities at different injection current levels at low temperature is discussed. The following conclusions are derived: As temperature falls, the current gain drops more significantly at low current levels. Because of the trapping effect of shallow level impurities at low temperature, the cutoff frequency also decreases. Finally, the paper describes the structure and fabrication method for a silicon bipolar transistor suitable for 77K operation.

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In-Situ Formation of YBaCuO Superconducting Film by Long-Pulse Laser Deposition

93FE0047B Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 20 No 8, Aug 92 pp 80-82

[Article by Zhang Fuquan [1728 3940 2938], Li Xiang [2621 1651], Pan Ping [3382 5493], and Xue Ruijun [5641 3843 0689] of Beijing Vacuum Electronics Research Institute, Beijing 100016: "In-Situ Formation of YBaCuO Superconducting Film by Long-Pulse Laser Deposition"; MS received Apr 91, revised Oct 91]

[Text] **Abstract**

A superconducting $YBa_2Cu_3O_{7-x}$ thin film has been formed in situ on a (100)YSZ single-crystal substrate by irradiating a target of high-temperature sintered $YBa_2Cu_3O_{7-x}$ with a long-pulse laser (pulse width 150 µs, wavelength 1.06 µm) under 6 Pa of oxygen pressure. The substrate is placed on a heater at 750°C. The distance between the target and the substrate is 5 cm. The thin film prepared appears to be bright and strong and it behaves as a metal. Its zero-resistance temperature is 84.7 K. The film has been analyzed by XRD (X-ray diffractometry) and SEM (scanning electron microscopy).

I. Introduction

Among many techniques available for preparing high-T_c superconducting films, laser deposition is capable of providing high-quality films with a narrow temperature transition range for resistance and a high critical current density. Most lasers used in research are short pulse (pulse width 1-100 ns) lasers, such as excimer lasers and Q-switched Nd:YAG lasers. They duplicate the target material stoichiometrically onto the substrate at a peak power density of 10^7-10^8 W/cm^2 and a low deposition rate to produce a superconducting thin film with a steep transition temperature and a high critical current density.

Although high-quality superconducting films can be prepared by short-pulse lasers, this technique is difficult to scale up for industrial use. First, the slow deposition rate prohibits high-speed production, which makes it less efficient. Next, due to the narrow angular distribution of the evaporated particles, it is very difficult to deposit a uniform film onto a large substrate.[1] Third, lasers are costly and expensive to maintain. Can high-quality superconducting films be prepared by conventional long-pulse lasers? The work done by M. Balooch[2] et al. showed that a 0.5-ms-pulse-width Nd:glass laser could be used to deposit a film of the same composition as that of the target on a 1-cm-diameter $SrTiO_3$ substrate at a very high rate. We used a 150-µs Nd:YAG laser to prepare a superconducting thin film with a zero-resistance temperature of 84.7 K on a single-crystal YSZ (yttrium stabilized zirconium oxide) substrate. Based on our preliminary work, it is feasible to use a long-pulse laser to prepare high-quality superconducting films. This is an area worthy of additional research.

II. Experimental Method

Figure 1 shows the experimental apparatus. The laser beam is generated by a conventional long-pulse Nd:YAG laser. The laser parameters are: wavelength 1.06 μm, pulse width 150 μs, energy per pulse 1 J, and repetition frequency 1 Hz. The laser beam passes through a window to enter the vacuum chamber and is focused on the target to form a 2-mm-diameter spot with energy density of approximately 33 J/cm^2. The target is a 28-mm-diameter, 5-mm-thick pellet of superconducting $YBa_2Cu_3O_{7-x}$ (YBaCuO) which is prepared by pressing a mixture of analytical grade Y_2O_3, CuO and $BaCO_3$ powders and sintering the pellet at high temperature for several hours. A polished and cleaned (100)YSZ single-crystal substrate is placed on a heater which is kept at 750°C. The temperature of the heater is measured with a platinum-platinum rhodium thermocouple. The substrate surface temperature is 100-200°C lower than that of the heater. The background pressure of the vacuum chamber is $P_0 \leq 4 \times 10^{-3}$ Pa. The target is rotated by a motor. An oxygen nozzle is used to blow oxygen onto the substrate surface (see Figure 1). The oxygen pressure used is about 6 Pa and the deposition time is 15-20 minutes. The film deposited is treated in oxygen in-situ for 40 minutes after the heater temperature is lowered to 650°C. It is then cooled to ambient temperature. The superconducting film thus prepared is bright and robust and has a thickness of 0.6-0.8 μm.

In-situ pulse laser deposition of superconducting YBaCuO film is determined by substrate, substrate temperature, oxygen pressure, thermal treatment and deposition apparatus; this includes laser parameters, substrate-to-target distance and oxygen nozzle position. Substrate material and temperature are selected based on requirements associated with epitaxial YBaCuO film. It has been illustrated both in theory and practice that Y, Ba, Cu and O atoms escape from the target at different speeds upon laser irradiation. The Cu atom is the fastest, followed by Y and Ba, and O is the slowest. Hence, they arrive at the substrate surface at different times. This is analogous to layer evaporation. Despite suitable stoichiometry, it is impossible to grow an epitaxial film. J. P. Zheng[3] et al. pointed out that the velocity distribution of various constituents is a function of laser energy density, gas pressure and substrate-to-target distance. Various constituents could reach the substrate surface at the same speed as a result of energy exchange after traveling some distance at a suitable gas pressure. Under our experimental conditions, the suitable oxygen pressure was found to be 6 Pa and the substrate-to-target distance was 5 cm. The presence of oxygen during deposition also helps replenish the oxygen content in the thin film.

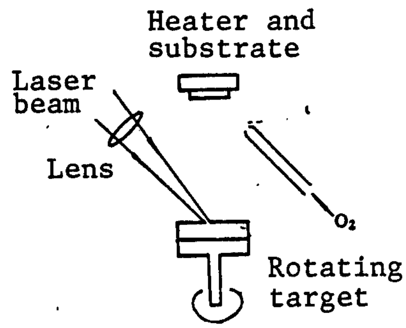

Figure 1. Schematic Diagram of Laser Deposition System

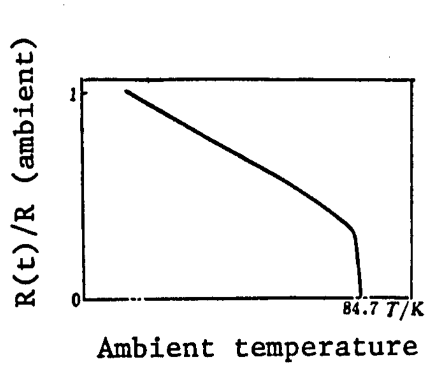

Figure 2. Resistance Versus Temperature of YBaCuO Superconducting Film on (100)YSZ Single-Crystal Substrate Formed by In-Situ Deposition With a Long-Pulse Laser

III. Experimental Results and Discussion

Figure 2 shows the resistance versus temperature curve of the YBaCuO superconducting film on (100)YSZ single-crystal substrate prepared by pulse laser in-situ deposition as measured by the CAS Institute of Physics using a four-point method. The zero-resistance temperature is 84.7 K and the transition temperature is approximately 2 K wide. As far as we know, this is the first superconducting film prepared by in-situ deposition with a long-pulse laser.

Figure 3 shows the XRD pattern of the film. Comparing the number of counts of the (200)s line to that of (00L), we can see that the former is lower. This might be due to a slight deviation of orientation of the (100)YSZ substrate during cutting and/or polishing. This causes the mismatch of lattice constant between the film and substrate to increase and hampers the epitaxial growth of the film. Despite this fact, from the narrow line width and extreme low background, the crystallization of the film remains excellent.

Figure 4 [photograph not reproduced] shows the morphology of the film by means of SEM. It illustrates the

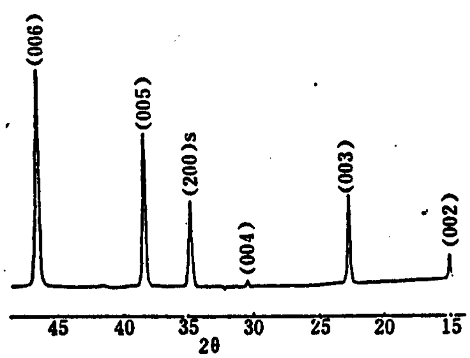

Figure 3. XRD Pattern of YBaCuO Superconducting Film on (100)YSZ Single-Crystal Substrate Formed by In-Situ Deposition With a Long-Pulse Laser

microcrystalline nature of the YBaCuO film. In addition, there are a number of aggregates of different sizes scattered across the film surface. The cause of the formation of these islands and methods for eliminating them are being investigated.

IV. Conclusions

For the first time, a YBaCuO superconducting film with an 84.7 K zero-resistance temperature has been prepared by means of in-situ deposition with a long-pulse laser. The film is shiny and robust and appears to be microcrystalline. The formation conditions are: laser energy density 33 J/cm^2, substrate heater temperature 750°C, substrate-to-target distance 5 cm, oxygen pressure during deposition 6 Pa, and 40 minutes of post-deposition in-situ treatment in oxygen at 650°C prior to cooling to room temperature.

The work is preliminary in nature. The growth conditions have not been optimized and improvements are still required.

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Preparation of High-T_c Superconducting Films on Sapphire Substrate

93FE0047C Hefei DIWEN YU CHAODAO [CRYOGENICS AND SUPERCONDUCTIVITY] in Chinese Vol 20 No 3, Aug 92 pp 33-37

[Article by Han Chaolin [7281 2600 2651], Lu Yunrong [4151 0061 2837], Ma Jiyong [7456 4949 0516], and Luo Zhiliang [5012 1807 5328] of Institute 13 of MMEI, Shijiazhuang: "Preparation of High-T_c Superconducting Films on Sapphire Substrate"; MS received 11 Mar 92]

[Text] **Abstract**

Sapphire is very suitable for use in superconducting microwave devices due to its low microwave loss tangent. A high-T_c superconducting YBCO film has been successfully deposited on sapphire by means of DC magnetron sputtering and in-situ annealing with $T_c \geq 89$ K and $J_c = 1 \times 10^5$ A/cm^2.

1. Introduction

Most superconducting YBCO films are deposited on substrates such as ZrO_2, $SrTiO_3$, $LiAlO_3$ or MgO. These substrates have high microwave losses and are not suitable for use in superconducting microwave devices. The microwave loss tangent of sapphire is extremely low, which is favorable for a microwave device. Some work has been done in this area abroad.[1] We have obtained satisfactory results with bare sapphire using DC magnetron sputtering followed by in-situ annealing.

2. Apparatus

The apparatus used is a DC sputtering platform, as shown in Figure 1. The main features include an adjustable cathode ring for ease of specimen placement, a large rectangular heater, and the capability of placing 14 pieces of 5 x 10 mm^2 (or 6 pieces of 10 x 10 mm^2, or 3 pieces of 10 x 20 mm^2) substrate on three sides of the discharge ring. Furthermore, the heater can be moved three-dimensionally to an optimal position.

3. Experiment

3.1 Experimental Conditions

The conditions for depositing superconducting YBCO film on sapphire are different from those used for ZrO_2. The temperature range is 720°C to 740°C. This process is more temperature sensitive.

3.2 Deposition Rate

A study of the growth rate of YBCO film on ZrO_2 (100), ZrO_2 (110) and Al_2O_3 (1$\bar{1}$02) substrates shows that:

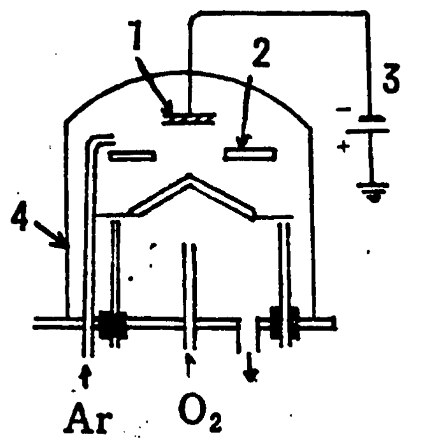

Figure 1. Apparatus

1. Magnetron target; 2. Anode; 3. DC power supply; 4. Bell jar

(1) It grew faster on ZrO_2 (110) than on ZrO_2 (100). When the rate for the former is 11.1 Angstroms/minute, that of the latter is 10 Angstroms/minute.

(2) ZrO_2 (100) is faster compared to Al_2O_3 (1T02). The latter is 9.7 Angstroms/minute under identical conditions.

(3) It grows faster at lower temperature; however, the film is not as tight. The film surface is piled up as carbon and it is not shiny and robust. It has very poor superconductivity.

3.3 Key Techniques and Measures

(1) Substrate

Crystal orientation is a key factor when depositing superconducting film on sapphire. Good superconducting YBCO films can only be deposited on Al_2O_3 (1T02) substrates. The choice direction of growth is along the C axis. Figure 2 shows the XRD pattern. The (001) peaks explain the selection of C axis for film growth.

(2) Surface

Normally, the preferred direction of growth is along the C axis (see Figure 2). The way to control the film to grow along the C axis includes:

a. Choose a suitable substrate, e.g., Al_2O_3 (1T02).

b. Control deposition rate.

c. Control film thickness. Normally, film thickness is around 1 μm. If it is too thick, there will be preferential composition along the a axis and b axis to lower J_c (see Figure 3). The computed point matrix constants are 3.825 Angstroms, 3.825 Angstroms and 11.708 Angstroms, respectively.

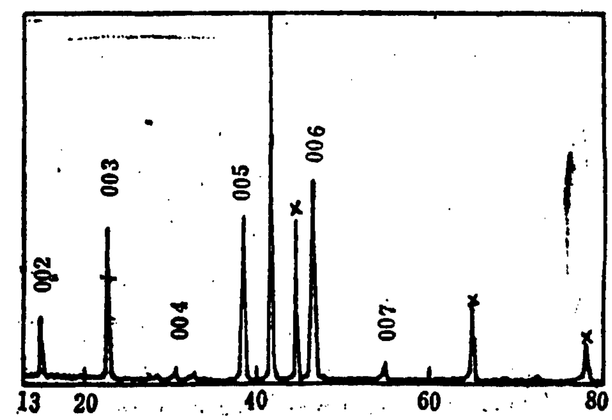

Figure 2. XRD Pattern (x represents substrate peak)

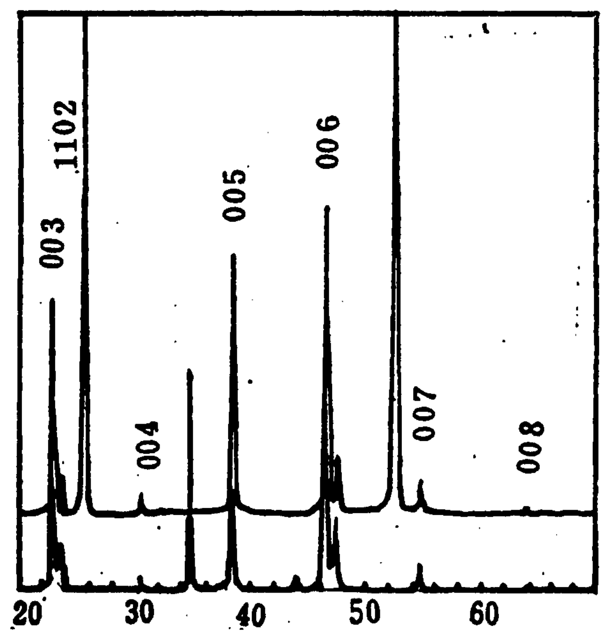

Figure 3. XRD Pattern; lower peaks to the right of (003) and (006) are due to a and b axis orientation. The peaks overlap because the point matrix constants for a and b axis are very close.

(3) Interface

Mutual interaction between the substrate and the film at the interface is a serious problem. Their mutual diffusion alters the film composition, which consequently seriously affects its superconductivity. This is particularly so when Al in the substrate diffuses into the film. Minimizing Al diffusion toward the film is a key technique. Presently, the method employed abroad[1] is to deposit a ZrO_2 blocking layer on sapphire. By doing so, although higher T_c and J_c could be obtained, significant microwave loss still remains because of the high microwave loss of ZrO_2. To this end, a high-T_c YBCO superconducting film was deposited on bare sapphire with good results. Al diffusion is effectively suppressed using an in-situ transition technique (as shown in Figure 4 [photograph not reproduced]).

As shown in Figure 4, there is a substantial amount of Al near the substrate, i.e., in the transition layer. Outside the transition layer, it is relatively low. There is almost no Al on the film surface. The specimen exhibits excellent superconductivity with a T_c of 89 K and $J_c > 10^5$ A/cm^2.

4. Special Features

4.1 Lower Sputtering Temperature

Low-temperature film deposition is a new direction in thin-film physics. Lower temperatures can minimize mutual diffusion of atoms at the interface to ensure its stoichiometry. Usually, the temperature used is above 850°C. The temperature used in this work is 720°C to 740°C, which results in higher quality superconducting films. The results are summarized in a table below. In general, $T_c \geq 89$ K and $J_c \geq 10^5$ A/cm^2.

4.2 No Buffer Layer

YBCO superconducting films are directly deposited on a bare sapphire substrate without a buffer layer. This paves the way for the use of superconducting films in microwave devices.

4.3 Larger Area Film

Numerous experiments were done using 10 x 10 mm^2, 8 x 16 mm^2 and 10 x 20 mm^2 Al_2O_3 substrates. The resistance was found to be evenly distributed, which indicates a certain degree of uniformity of superconductivity. Tables I and II show the resistance distributions of typical specimens (as measured by two probes).

Table I. Resistance Distribution Across Film on 10 x 10 mm^2 Sapphire Substrate

25	27	28
25	27	29
26	31	41

Table II. Resistance Distribution Across Film on 8 x 10 mm^2 Sapphire Substrate

27	30	26
25	27	26
38	35	31

From the resistance distribution shown, one can see that it is evenly distributed. Its nonuniformity is 5-12 percent crosswise and 2-6 percent longitudinally.

Thickness distribution experiment: Samples were found to be uniformly thick on a step meter.

4.4 Annealing Time

After sputtering, oxygen was passed at a high rate and temperature was allowed to fall rapidly and continuously over 2-10 minutes.

Normally, a method developed by Wang Shouzheng [3769 1343 6086] et al. in the Department of Physics at Beijing University[2] is used for in-situ annealing. This method involves the gradual lowering of temperature after sputtering to 700°C and maintaining the temperature for 30-60 minutes, followed by lowering the temperature to 500°C and keeping it at that temperature for 30-45 minutes, and cooling to room temperature. It requires a long period of time for annealing after sputtering. Fast annealing not only ensures film quality but also saves substantial amounts of time. The efficiency is improved.

5. Results and Discussion

Excellent superconducting YBCO films have been successfully prepared using existing equipment. Typically, $T_c \geq 89$ K and $J_c \geq 10^5$ A/cm^2. The best sample has a T_c = 91.5 K. These films have real potential for practical use. Table III shows a comparison with results obtained abroad.

Table III

	Institute 13	Foreign
T_c (K)	≥ 89	≥ 87
J_c (A/cm^2)77K	1 x 10^5	1 x 10^6
Substrate	Al_2O_3 (1T02)	Al_2O_3 (1T02)
With or without buffer	Without	With
Method	DC magnetron sputtering	Laser sputtering

Figure 5 shows a normal measured R-T curve. It indicates that T_c is 89 K and transition temperature is 94 K.

Currently, there are a few urgent problems to be resolved.

1. More effectively block Al diffusion toward the film and further reduce film thickness to raise J_c.

2. Improve the stability and reproducibility of the process in order to lay a solid foundation for small-scale production and device development.

3. Further enlarge substrate size and improve uniformity to expand the range of applications for the film.

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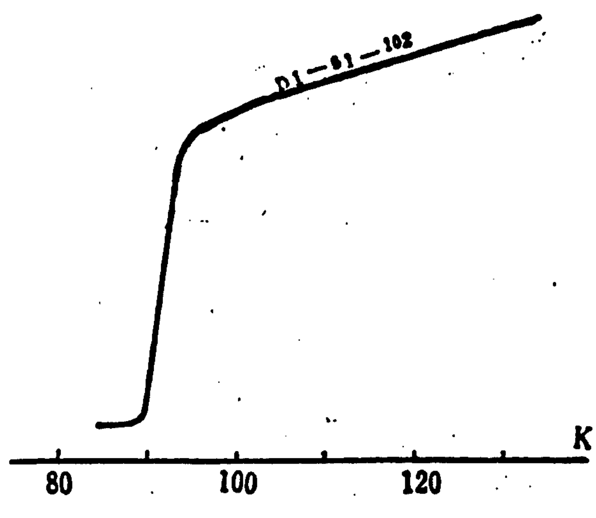

Figure 5. R-T Curve

2. Xiong Guangcheng [3574 0342 2052] and Wang Shouzheng, BOMO KEXUE YU JISHU [THIN FILM SCIENCE AND TECHNOLOGY], Vol 3, No 1, p 10.

Response of High-T_c Superconducting Josephson Junctions to Nuclear Radiation

93FE0047D Hefei DIWEN YU CHAODAO [CRYOGENICS AND SUPERCONDUCTIVITY] in Chinese Vol 20 No 3, Aug 92 pp 43-47

[Article by Ding Honglin [0002 3163 2651], Zhang Wanchang [1728 8001 2490], and Wang Jun [3769 6511] of China Institute of Atomic Energy, Beijing: "Response of High-T_c Superconducting Josephson Junctions to Nuclear Radiation"; MS received 17 Feb 92]

[Text] **Abstract**

An applied study on the effects of nuclear radiation on superconducting Josephson junctions using high-T_c YBCO films in cryogenic capsules is described. The study focuses on the following issues: 1) Selection of optimal bridge junction geometry for high-T_c YBCO film. Bridge junctions of different sizes, such as 2 x 2, 2 x 6, 3 x 30, 5 x 40, 10 x 50, and 20 x 60 μm^2, were fabricated on high-T_c YBCO films 2,000-3,000 Angstroms in thickness. Experimentally, it was found that 5 x 40 and 10 x 50 μm^2 junctions had the highest sensitivity to nuclear radiation. Signals already reached 40 μV without any amplification and rose with increasing source intensity. 2) Single pulse counting of 59.5 keV low-energy γ rays was observed with the use of a step-up transformer, preamplifier and spectrum amplifier. 3) The performance remained good after five temperature cycles. 4) The radiation resistance of the high-T_c YBCO film is related to its superconductivity. These results indicate that it is feasible to develop a high-T_c superconducting radiation detector to measure the energy spectrum of the radiation with a Josephson-junction-based high-T_c superconducting film.

1. Introduction

Andrews et al. first presented the feasibility of using a superconductor as a detector for α particles in 1949. After a decade, Sherma observed a transition of the superconducting film to its normal state as ionized particles passed by and the current declined. More than two decades later, the Swiss Nuclear Institute discovered a Sn-SnO_2-Sn single-electron tunneling-junction-based low-temperature X-ray detector that has an energy resolution better than that of the Si(Ci) detector. By 1988, the FWHM with respect to the 5.9 keV X-rays of ^{55}Fe has reached 48 eV. Nevertheless, because of its low operating temperature (below 1 K), the Sn-SnO_2-Sn single-electron tunneling junction has very poor temperature cycling behavior. To date, it is still a treasure in the laboratory and cannot be commercialized. Since the advent of high-T_c oxide superconductors in 1987, there has been a great deal of enthusiasm in the nuclear community for developing a new generation of radiation detectors based on high-T_c oxide superconductors.

2. Principle and Practice of Using High-T_c Superconducting Josephson Junctions To Measure Radiation Response

Since the discovery of high-T_c YBCO superconductors in 1987, we have spent over 3 years experimenting with YBCO bulk materials and thin films in cryogenic capsules to study high-T_c superconducting Josephson junctions with specific reference to nuclear radiation detection. Experimentally, we have confirmed that high-T_c superconducting film Josephson junctions have an excellent response to nuclear radiation.

2.1 The experimental apparatus is shown in Figure 1.

The apparatus is powered by a DC constant-current supply capable of pulling a vacuum and reaching a temperature of 79 K. It also has an electrically shielded low-temperature case and a step-up transformer coupled with a fast preamplified and spectrum amplifier. An oscilloscope is used to observe the signal and a calibrator is used for counting.

2.2 Principle of Measurement of Radiation Response Using a High-T_c Superconducting Josephson Junction

The variation of the normal electron tunneling current in the DC I-V characteristics of the superconducting weak link is used to measure nuclear radiation.

A DC current bias I_t is applied to the weak link (bridge junction). In addition, I_b is greater than I_c. Thus, there is a DC voltage drop across the bridge junction. This voltage drop, on one hand, helps collect quasi-particles (normal electrons) formed by the radiation. This is of course desirable. On the other hand, since we are operating in the non-zero voltage region slightly higher than

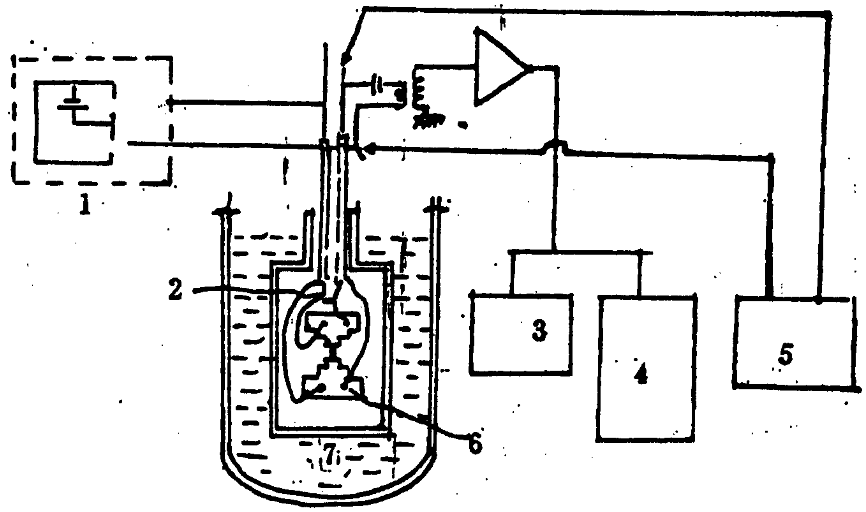

Figure 1. Experimental Apparatus

1. Constant-current source (operating bias current); 2. α, β and γ radiation source; 3. Oscilloscope; 4. Multichannel analyzer; 5. 6 1/2-digit voltmeter; 6. Detector; 7. Liquid nitrogen

I_c, there is alternating superconducting current present in the bridge junction which may appear in the form of noise. This is detrimental to our measurement. Hence, we must choose the optimal DC bias current I_b in order to have the best result.

When a DC bias working point in a region where I_b is greater than I_c is selected, the bridge junction is in a mixed normal and superconducting hybrid state. The current passing through the junction is the normal electron tunneling current and the alternating superconducting current. Only the normal electron tunneling current produces a voltage drop across the bridge junction. When radiation enters the bridge junction, the incident particle interacts with the superconducting electron pair (Cooper pair) and a portion of the energy of the incident particle is absorbed by the superconducting electrons. This causes the breakup (excitation) of a number of Cooper pairs to become normal individual electrons. Consequently, the normal electron current in the tunnel junction is increased and the voltage across the junction also rises. The intensity of the incident radiation can be determined by measuring this voltage which reflects the interaction between this junction and radiation.

3. Experimental Results

Figures 2, 3, 4, and 5 show the response of high-T_c superconducting YBCO bridge junctions to different radiation rays.

Figure 2 shows the response of a high-T_c YBCO bridge junction (10 x 50 μm^2) to 50 mci 59.5 keV low-energy γ rays of ^{241}Am.

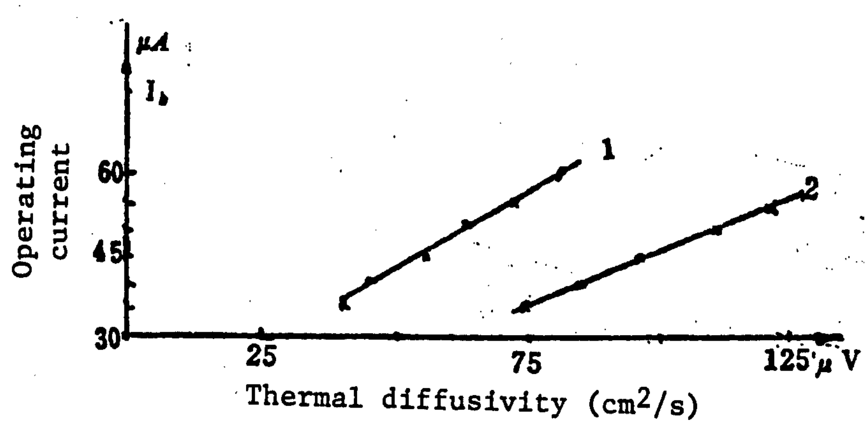

Figure 2. Output Voltage of High-T_c YBCO Bridge Junction With and Without 50 mci 59.5 keV γ Rays

1. I_b-V curve without radiation; 2. I_b-V curve with radiation

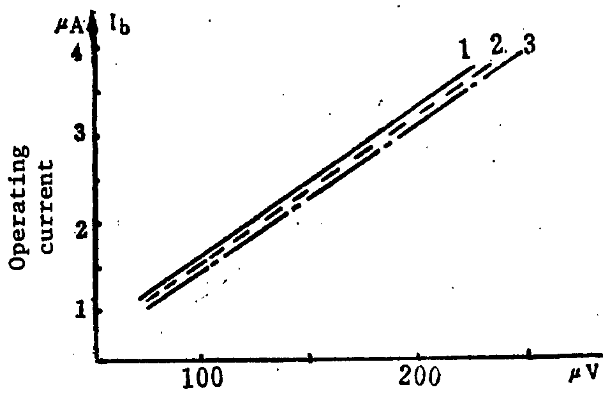

Figure 3. V-I Curves of a 20 x 60 μm² High-T_c YBCO Bridge Junction at Different γ-Ray Intensities

1. I_b-V curve without radiation; 2. I_b-V curve with 10 mci ^{241}Am 59.5 keV γ radiation; 3. I_b-V curve with 50 mci ^{241}Am 59.5 keV γ radiation

Figure 3 shows the response of a high-T_c YBCO bridge junction (20 x 60 μm²) to ^{241}Am 59.5 keV γ rays at different intensities (i.e., 10 mci and 50 mci).

Figure 4 shows the response of a high-T_c YBCO bridge junction (10 x 50 μm²) to a Sr-Y β source (3 mci).

Figure 5 shows how the radiation count rate of a 10 x 50 μm² high-T_c YBCO bridge junction varies with operating current in the presence of a Sr-Y source.

In addition, temperature cycling and radiation resistance experiments were done on the high-T_c thin film bridge junctions. After measurements were taken in a cryogenic vacuum chamber at 79 K, the vacuum chamber was returned to room temperature for 80 hours and then cooled down to 79 K for additional radiation measurements. Results remained unchanged. After five temperature cycles, returning to ambient pressure and then taking measurement in vacuum and low temperature

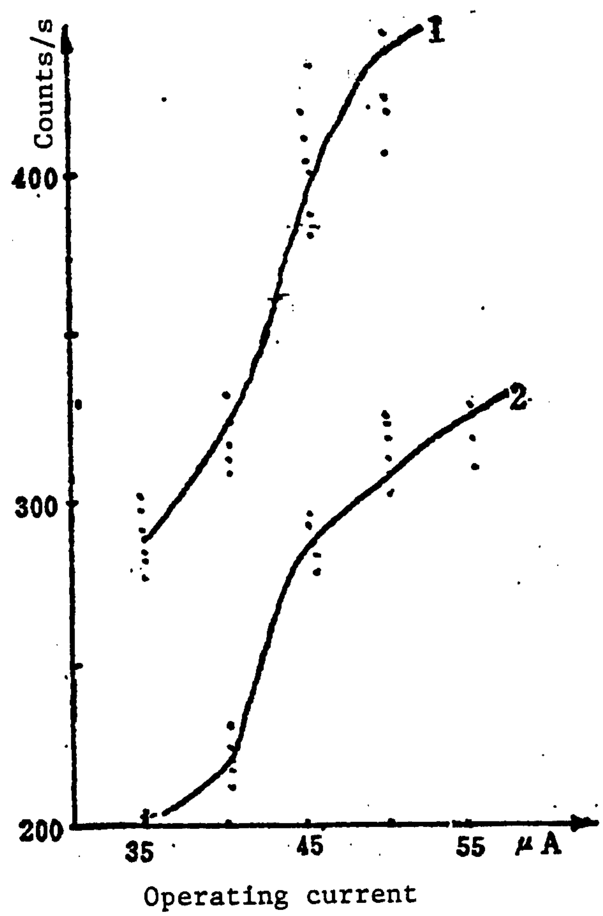

Figure 5. Count Rate vs. Operating Current of a 10 x 50 μm² High-T_c YBCO Bridge Junction in the Presence of a 3 mci Sr-Y β Source

1. With 3 mci Sr-Y β source; 2. Without radiation source

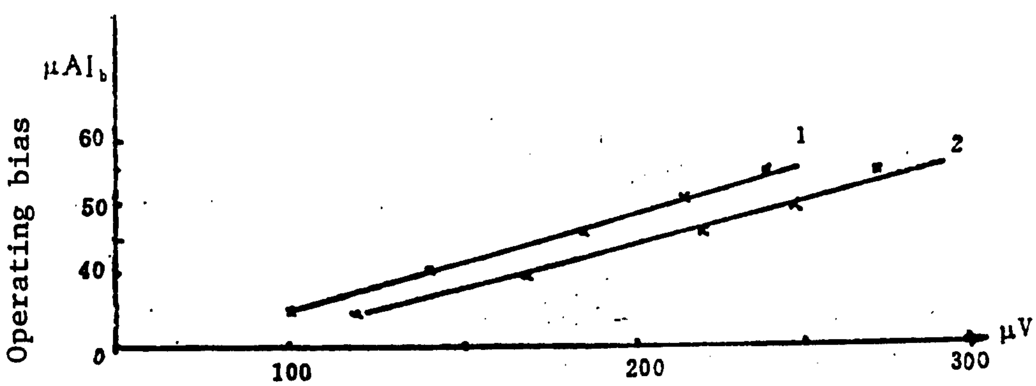

Figure 4. Response of High-T_c YBCO Bridge Junction (10 x 50 μm²) to a 3 mci Sr-Y β Source

1. I_b-V curve without radiation; 2. I_b-V curve with 3 mci Sr-Y β source

every time, behavior was found to be stable. The radiation resistance of a high-T_c superconducting radiation detector is related to its superconductivity. The radiation resistance of a high-quality, high-T_c Josephson junction is similar to that of a semiconductor detector.

4. Conclusions

The results of using thin-film high-T_c YBCO bridge junctions to measure low-energy γ and β radiation, especially the variance of count rate with operating bias current in the presence of a Sr-Y β source, demonstrate that it is feasible to develop a high-T_c Josephson junction radiation detector capable of measuring the radiation spectrum. A great deal of experience and data has been acquired in this work. Different high-T_c film Josephson junctions, such as bridge junctions of different geometric sizes, edge and mesa SNS junctions, will be fabricated. Suitable preamplifiers will be selected to evaluate the performance of various high-T_c superconducting radiation detectors.

Southern Seacoast Fiber Optic Cable Trunkline Operational

93P60068A Beijing RENMIN RIBAO [PEOPLE'S DAILY OVERSEAS EDITION] in Chinese 25 Nov 92 p 1

[Article by Yan Bing [0917 0393]: "Southern Seacoast Fiber Optic Cable Trunkline Operational"]

[Summary] Shanghai, 24 Nov (RENMIN RIBAO wire report)—The southern seacoast fiber optic cable trunkline—to date, the fastest laid, longest range, highest capacity technologically advanced fiber optic cable trunkline in China—became formally operational today in Shanghai. This line, which will raise seacoast long-distance communications ability by a factor of 10, runs north to south through 72 cities, chief among which are Nanjing, Shanghai, Hangzhou, Ningbo, Wenzhou, Fuzhou, Xiamen, Chaozhou, Huizhou, and Guangzhou. The main line has connections in Nanjing for Beijing and Hubei Province, in Shanghai for Japan and other eastern points, in Fuzhou for Jiangxi Province, and in Guangzhou for Jiangxi Province, Hunan Province, Guangxi Province, and Hainan Province; in addition, there are branch lines from Chaozhou to Shantou, and from Huizhou to Shenzhen, with connections in Shenzhen to Hong Kong. The line thus connects Shanghai with Jiangsu, Zhejiang, Fujian, and Guangdong Provinces. Built at a gross investment cost of 460 million yuan including US$40 million, this trunkline is 2,896 kilometers in total length, uses 24-fiber cable, and includes a DS4 [140 Mbit/s] optical communications system. So far, 5,000 circuits have been opened up, and before the year's end an additional 10,000-plus circuits are scheduled to be operational.

Sino-Russian ECRH Experiment With HL-1 Tokamak Successful

93P60067A Shanghai WEN HUI BAO in Chinese 3 Nov 92 p 1

[Article by Liu Xiaoge [0491 1420 7245]: "Nation's Controlled Nuclear Fusion Research Strides Into New Phase"]

[Summary] Chengdu, 2 Nov (XINHUA)—Scientists at the China National Nuclear Corporation's Southwest Institute of Physics, in cooperation with colleagues from Russia's Ioffe Physico-Technical Institute, recently conducted an experiment with the HL-1 tokamak—the nation's largest controlled nuclear fusion apparatus—in which electron cyclotron resonance heating (ECRH) was successfully realized. In this experiment, concluded at the end of October, plasma electron temperature increased 30 percent [compared to previous experiments]. The ECRH system used in the experiment was jointly constructed by the Southwest Institute of Physics, Russia's Institute of Applied Physics, and the CAS Institute of Physics.