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Japan Report

SCIENCE AND TECHNOLOGY

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JAPAN REPORT

SCIENCE AND TECHNOLOGY

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AIRCRAFT INDUSTRY VIEWS LINK WITH BOEING

Tokyo AEROSPACE JAPAN in English Apr 86 p 69

[Text]

McDonnell Douglass recently won firm order for 30 MD-88 jets plus 50 on option from Delta Air Lines. The news upset the Japanese aircraft industry which aims at developing the 7J7 new airliner with Boeing Co.

The Boeing 7J7 program is aimed at developing a new 150-seat class passenger plane powered by UHB (Ultra High-Bypass) engines. The development program had relied on Delta Air Lines as the kick-off customer. While postponing the Delta 3 program to introduce new 150-seat class passenger planes, Delta has bought neither Boeing 737-300 nor Airbus Industrie A-320. Moreover, the airline has shown no interest in the Boeing 757 or the 7-7 either. Since Delta decided to buy as many as 80 MD-88 jets, the Japanese industry is concerned that the Boeing 7J7 lost the biggest potential customer.

In collaboration with Boeing, Japan has spent a long period of time in studying feasibility of developing the 7 X 7 and the 7-7 planes but neither of them has been realized. In other words, Japan is just waiting for Boeing to launch a new airliner development. If the 7J7 program should be given up too, many experts are concerned that the world's market of the 150-seat class airliners should be dominated by either Airbus Industrie A-320 or McDonnell Douglass MD-88. As a result, there would be no chance for Japan to make forays into this market by collaborating with Boeing.

On the other hand, there are quite a few Japanese people who are disappointed with Boeing's negative attitude toward the V2500 engine. McDonnell Douglass too seems unlikely to adopt the V2500 for its planes since the V2500-powered MD-89 jet development program did not attract interest of the airlines as much as expected.

In such circumstances, the three major Japanese aeroengine manufacturers expect All Nippon Airways to select the Airbus A-320, the sole 150-seat class passenger jet to be powered by the V2500 engines, to replace the Boeing 727 and 737 jets. The Japanese aeroengine manufacturers are said to be asking the Japanese government (the Ministry of International Trade and Industry) to press ANA to select the A-320.

/13046
CSO: 4307/17

TRDI UNVEILS T-2KAI CCV EXPERIMENTAL PLANE

Tokyo AEROSPACE JAPAN in English May 86 p 65

[Text]

The Defense Agency's Technical Research and Development Institute (TRDI) made demonstration flights of the T-2 modified CCV (control-configured vehicle) experimental plane on March 20 at the Air Self-Defense Force's Gifu Air Base.

The CCV experimental plane is a modified version of the domestically developed Mitsubishi T-2 supersonic advanced trainer. Its purpose is to gain basic data to improve manoeuverability of high-speed aircraft such as fighters. Its design work began in 1978 and the prototype production started in 1979. Since the first flight was made at Mitsubishi Heavy Industries' Komaki-Minami Plant in August 1983, the experimental plane has undertaken various tests.

The plane is fitted with horizontal canard wings on the air inlet in the forward section of the main wing and a vertical canard wing beneath the middle section of the fuselage. The navigation system is also remodeled as the fly-by-wire system. As of march 18, 1986, the plane completed 138 flights.

/13046
CSO: 4307/18

MITI EXPECTS ANA TO SELECT V2500-POWERED A320

Tokyo AEROSPACE JAPAN in English May 86 p 65

[Text]

Asked at a Diet session on March 25 about the V2500 and the YXX projects concerning their development schedules and prospects for profitability, Machinery and Information Industry Bureau Director General Hiromichi Sugiyama of the Ministry of International Trade and Industry (MITI) said, "The first V2500 engine is due to be delivered to a customer in 1988. As for the prospects for profitability, the V2500 project is estimated to earn profits on a single year basis in four to five years from the first delivery, although it depends on the pace of deliveries. On a cumulative basis (including development costs), profits are expected around 2000. When the engine sells 4,000 units, the project makes both ends meet on a cumulative basis too. In the case of the YXX, on the other hand, although the date of the first delivery has not been decided yet, the development will be carried forward with a view to beginning deliveries in 1991. (Regarding the prospects for profitability), single-year profits are expected in four to five years from the first delivery. On a cumulative basis, the YXX project is expected to make both ends meet around 2005 and to earn profits onward. The YXX project is expected to sell at least 6,000 aircraft."

Regarding the publicity and sales plans of the two projects as well as their relations with the Japanese airlines, Sugiyama also said, "We expect the Japanese airlines to use the V2500 and the YXX as a fruitful result of the Japanese aircraft industry's participation in the two international joint development efforts. Airbus Industrie A320 is the only aircraft (at present) to be powered by the V2500. Any of the Japanese airlines have not yet adopted the A320. We understand that All Nippon Airways has listed the A320 as one of the candidates for a new 150-seat class passenger plane to be introduced. (If ANA should choose the A320), the airline is due to adopt the V2500. So, we rather expect ANA to use the A320. In this respect, we understand that the makers engaged have been publicizing the V2500 to the airlines. The YXX has not yet progressed as much as the V2500. Full-scale sales activities of the YXX will be commenced in or after the summer of the next year.

In the meantime, the government authorities concerned including MITI have emphasized that they would remain neutral as far as the airlines' aircraft selection is concerned.

/13046
CSO: 4307/18

JAPAN AEROSPACE INDUSTRY'S FY 85 SALES ESTIMATED AT Y820 BILLION

Tokyo AEROSPACE JAPAN in English Jul 86 pp 72

[Text]

The figures summed up by the Society of Japanese Aerospace Companies (SJAC) show that the total output of the Japanese aircraft industry (including aeroengines, components, instrument, communications equipment, tires and tubes and so on) amounted to ¥636,448 million in FY'85 (April 1985 – March 1986), up 9.4% from the previous fiscal year.

This total was counted up statistically. Another figures also summed up by the SJAC in a report on Japan's space industry reveal that the sales are estimated at ¥180.3 billion for the same fiscal year, although the accuracy of the figures in this report are not as high as the other's. Adding these figures together, the overall sales of the Japanese aerospace industry as a whole are estimated to reach some ¥820 billion for FY'85. Further details are shown as follows:

The number of aircraft produced in the fiscal year was 118. The sales of aircraft production amounted to ¥216,994 million and that of aircraft repairs to ¥29,910 million. The aircraft production break down to 101 aircraft (¥211,900 million) for the Defense Agency, 7 aircraft (¥2,500 million) for the domestic commercial market, and 10 aircraft (¥2,600 million) for exports.

The number of aeroengines built was 114 units or equivalent to ¥105,900 million. The engine repairs totaled ¥13,335 million. The engine production breaks down to 105 units (¥88.600 million) for the Defense Agency and 9 units (¥12,900 million) for the domestic commercial market.

As for other aircraft-related production, airframe parts and equipment amounted to ¥142,234 million, support equipment to ¥19,689 million, instrument to ¥24,769 million, training devices to ¥9,404 million, accessories to ¥6,994 million, radios to ¥19,705 million and tires/tubes to ¥1,577 million.

The total sales of aircraft production and repairs break down to ¥530,556 million from the Defense Agency (accounting for the largest share of 83.4%), ¥3,004 million from the U.S. forces in Japan (0.5%), and ¥57,946 million from the domestic civil demand (9.1%).

/13046
CSO: 4307/14

ARIANESPACE WINS CONTRACT TO LAUNCH JAPAN'S SATELLITE

Tokyo AEROSPACE JAPAN in English Jul 86 p 73

[Text]

Arianespace announced on May 12 that the company signed an official contract with Hughes Communications to undertake an launch of the first telecommunications satellite, named "JCSAT-1," of Japan Communications Satellite Corp., a Japanese private satellite communications service company.

According to the contract, the JCSAT-1 will be launched into a geostationary transfer orbit in February 1988 by the Ariane 4, the most powerful satellite launch vehicle now available in the Ariane series rockets. The rocket will be lifted off at the new facility ELA-2 of the Guiana Space Center in Kourou, Guiana.

The JCSAT-1 is a large-capacity new generation satellite developed by Hughes Aircraft. It weights 2,280 kilograms when launched. Japan Communications Satellite Corp. is a joint venture established by C. Itoh Co., Mitsui & Co. and Hughes Communications.

Arianespace Chairman Frederic D'Allest said, "This contract has great significance in two senses. One is a successful business achieved in the Japanese market, and the other is our close relationship with American satellite makers.

As a result, Arianespace has won firm orders for launching 48 satellites, of which order backlogs are 32 satellites equivalent to 10 billion francs (approximately US$1.5 billion or ¥238 billion).

/13046
CSO: 4307/14

LOCAL GOVERNORS AGREE TO PROMOTE COMMUTER AIR TRANSPORT

Tokyo AEROSPACE JAPAN in English Jul 86 p 73

[Text]

Prefectural governors from the Western Seto Region met on May 13 in Ehime Prefecture and they agreed to facilitate early establishment of commuter air transport system.

The prefectures concerned will be giving an all-out support to Nihon Sangyo Koku Co. Ltd., one of the major commercial aircraft operators in Japan, which is due to apply for a license to operate point-to-point air transport service (semi-regular commuter air service) between Oita and Matsuyama in June.

As for airports for such commuter air services, Kochi Prefecture and Oita Prefecture plan to construct their respective airports and expect to incorporate them in the central government's 5th Airport Improvement Plan.

In the meantime, the seven prefectures concerned completed their joint surveys for estimate of the demand for commuter air transport in the region. According to the surveys, the heaviest passenger traffic is estimated at 163,000 passengers yearly between Hiroshima and Matsuyama in 1990. This is followed by 77,800 passengers between Oita and Hiroshima and 51,300 passengers between Oita and Matsuyama.

The surveys were contracted to Mitsubishi Research Institute, one of the major private research institutes in Japan. Analyses of the demand were made on two cases because the air fares of commuter air routes are estimated to be higher than that of scheduled air routes. One case is 20% high fares per kilometer and the other is 30% higher.

In case of the Oita-Matsuyama route, the number of passengers are estimated at 78,000 with an air fare of ¥11,000 or 51,200 with an ¥12,000 air fare on the basis of six round-trip flights a day.

In opening commuter air routes in the West Seto Region, it is believed economically efficient to link Matsuyama, Hiroshima and Oita in triangle. But there is a newly established commercial aircraft operator in Hiroshima and this new company plans to operate between Hiroshima and Matsúyama in the future. So, Nihon Sangyo Koku can hardly establish the ideal triangle route network lacking the Hiroshima-Matsuyama sector. To improve operational efficiency, Nihon Sangyo koku plans to open a new route across Shikoku Island between Matsuyama and Yao via Tokushima in the near future.

/13046
CSO: 4307/14

SHORT BROTHERS NAMES NEW JAPANESE SALES AGENCY

Tokyo AEROSPACE JAPAN in English Jul 86 p 73

[Text]

C. Itoh Aviation Co., Ltd. announced on May 25 that the company signed a sales agency contract with Short Brothers Plc. to promote sales of Shorts 330/300 series commuter planes in the Japanese market.

Short Brothers is one of the traditional aerospace makers in the world. It products include Blowpipe Portable SAM and Sea Wolf surface-to-air missiles as well as Shorts SC.7 Skyvan/Skyliner light transports with unique design of which priority is given to practical use.

As the sales agency contract with Kyoei International had expired late last year, C. Itoh Aviation negotiated with Short Brothers for the sales agency contract. Since C. Itoh is the sales agency for Beechcraft and Canadair too, Short Brothers awarded the contract to the company after confirmation that Shorts 330/360 planes do not compete with the American and the Canadian makers' aircraft in the Japanese market.

/13046
CSO: 4307/14

SEMICONDUCTORS, CONDUCTING POLYMERS USED AS PHOTOCATALYSTS

Tokyo KINO ZAIRYO in Japanese Oct 85 pp 36-46

[Article by Katsumi Yoshino, assistant professor, Department of Electric Engineering, Faculty of Engineering, Osaka University, and Shozo Yanagida, assistant professor, Department of Process Engineering, Faculty of Engineering, Osaka University]

[Text] 1. Introduction

It seems unlikely that the extensive use of fossil fuel such as coal and petroleum can be secured on a long-term basis in the future. During the oil crisis we have experienced manipulation of the supply and demand of petroleum by individuals which could develop into other social problems. In addition, coal and petroleum are known to cause environmental pollution which can seriously affect our society. For these reasons, it is now urgent to develop new sources of energy which provide large amounts of energy efficiently without air pollution. For similar reasons, the development of new, clean resources as well as the development of energy-saving chemical processes is desired.

The utilization of solar energy, which is readily available on earth, can be regarded as the most effective and natural solution. New light-utilizing processes are applicable to various fields where they will create new possibilities. One of the methods of utilizing solar energy is to convert it into electric energy. This method has been adopted by solar cells which utilize semiconductors (Si, etc.), wet solar cells and power stations which utilize solar heat. Another method of solar energy utilization is the method of producing hydrogen as an energy source from the photochemical reaction of water. Of course, the hydrogen (H_2) thus produced can be used also as a clean raw material in chemical and other industries. In other words, we may say that the production of H_2 from H_2O with the use of solar light is one of the most effective means of solving both current problems, i.e., the problem of energy and the problem of resources. Also this theme of research has an important meaning for the future of human beings in that it can help prevent the elevation of ambient CO_2 caused by the massive consumption of petroleum, coal, and natural gas and accompanied by environmental destruction on a global scale. Needless to say, such photochemical reactions are also industrially important, because they can be utilized for synthetic reactions (reduction, isomerization, etc.) of various materials. Furthermore, photochemical reactions are a very interesting aspect of basic science, because they are associated with the genesis and mechanisms of life.

Of the conventionally utilized techniques for photochemical production of H_2 from H_2O, a well-known technique involves platinum-deposited semiconductors (among others TiO_2).[1] In addition to this, positive research has been made on various photochemical oxidation and reduction reactions with the use of a semiconductor-platinum system serving as a catalyst.[2] The authors have been recently studying a system which utilizes ZnS powder but does not necessitate the deposition of platinum or other impurities. This system proved capable of photochemically reducing water into hydrogen efficiently and of selectively inducing photochemical oxidation and reduction reactions in which electron donors are involved.[3,4]

In recent years, active research has proceeded on new materials called conducting polymers.[5,6] The applications proposed so far of these highly conductive polymers include not only conductors, but various specialty materials such as secondary batteries,[7] solar cells,[8] solar functional elements,[9,10] and sensors.[11] It occurred to the authors that these conducting polymers might be utilized as photocatalysts in chemical reactions. Based on this idea, the authors have been carrying out research. Findings show that the use of these photocatalysts make possible hydrogen generation,[12] isomerization, and other reactions.[13]

In this paper, the authors will discuss the applications of inorganic semiconductive minute powders (ZnS, etc.) and conducting polymers (polyparaphenylene, etc.) as photocatalysts. The authors think that one of the characteristics of minute powders or conducting polymers is the formation of localized energy levels on their surface.

2. Basic Features of Semiconductors and Conducting Polymers

Although semiconductors are well known, first a brief summary of semiconductors. The semiconductors which are used in photochemical reactions have a prohibitive bandwidth of several eV. The electroconductive capacity of semiconductors is due to the electrons present in the conduction band and to the positive holes in the valence band. In n-type semiconductors, electrons play a principal role, while in p-type semiconductors positive holes play a principal role. The Fermi level is located near the conduction band (n-type) or the valence band (p-type). Basically, irradiation with light having energy greater than the width of the prohibitive band results in absorption of light from the valence band to the conduction band, leading to electron excitation. As a result, holes are produced in the valence band and electrons are generated in the conduction band. These electrons are brought to the surface by diffusion etc., thus initiating reactions in the interface with liquid. Actually, the electric fields produced by the interfacial shot key barrier, etc., help such movements. The color of semiconductors is determined by this interband absorption. The relationship between the energy at the lower edge of the conduction band, the upper edge of the valence band and the Fermi level, as well as the oxidation and reduction potential of a solution system, is important.

When electrons and holes appear in the interface at the same time, they disappear due to rebinding; therefore, efficiency lowers. For this reason, platinum or another impurity is deposited on the surface of TiO_2, etc., which

allows easier charge separation. When using a semiconductor as a catalyst, efficiency is improved by using the semiconductor in the form of fine powder. The major reason for improved efficiency is that fine powder has a larger surface area. For example, AnS and polyparaphenylene, which the authors have been using, have large surface areas of ca. 140 m^2/g and ca. 40 m^2/g, respectively. Additionally, we may expect a change in the band gradient when fine powder has a grain size almost equal to the width of a shot barrier. Also, a change in the prohibitive bandwidth itself is seen with extremely fine powders.[14] Thus, the use of fine powder has significant influence. At the same time, however, the authors see the necessity to point out that the use of fine grain leads to many flaws on the surface of semiconductors and that many localized levels may be formed within the prohibitive bandwith by such flaws. The electrons and holes captured by this kind of energy level can be said to have a long lifespan. When the energy of such a localized level is equal to the oxidation-reduction potential of a solution system, the efficiency of photochemical reactions may be substantially improved. In fact, such improvements are probable because localized levels have a wide distribution. The electrons and holes captured by local levels are chemically known as radicals; hence, they can be utilized as a source of radicals in a heterogenous system. Further, it is possible that the presence of localized levels contributes to the separation of electrons and holes.

As stated later in this paper, even the single use of fine ZnS powder is effective for the photochemical production of H_2 from H_2O. The reason for this is that the reduction potential of electrons is generally on the minus side. The conduction band of ZnS is -1.83 V vs. NHE (pH 7). This figure indicates that AnS has a reduction potency comparable to that of strontium amalgams.

Conducting polymers are polymers which have a highly advanced conjugated system of main chains. In these polymers, π-electrons play a principal role in electric conduction. In recent years, methylbiologen and various pigments, which are polymers that have photoreactive groups in the main or side chains, have been highlighted as photocatalytic polymers.[15,16] In these polymers, main chains are made of saturated bonds; hence, they can be called electron-relay-utilizing photocatalytic polymers. These polymers are totally different from the photocatalysts which are conducting polymers shown.

Figure 1 shows the molecular structure of representative conducting polymers. The width of the prohibitive band is determined by the molecular structure and the degree of advancement in the conjugated system. In many cases, the width is several eV. Although the conductivity of conducting polymers themselves is not very large, deposition of a very small quantity of halides (I_2, Br_2, etc.), Lewis acids (AsF_6-, BF_4-, ClO_4-, etc.) or alkaline metals (Na, K, Li, etc.) leads to a 10-digit or more rise in electric conductivity, i.e., an electric conductivity comparable to that of metals. In other words, deposition of such impurities transforms the polymers from insulators into metals.

Conducting polymers before or after deposition of very small quantities of impurity can be regarded as semiconductors (polymer semiconductors) having a prohibitive bandwidth of several eV. Therefore, when excited by light,

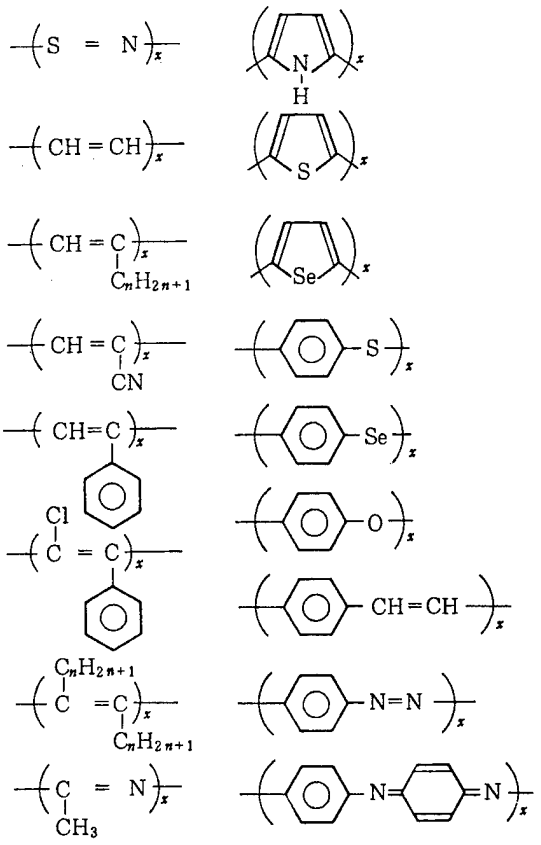


Figure 1. Examples of Conducting Polymers

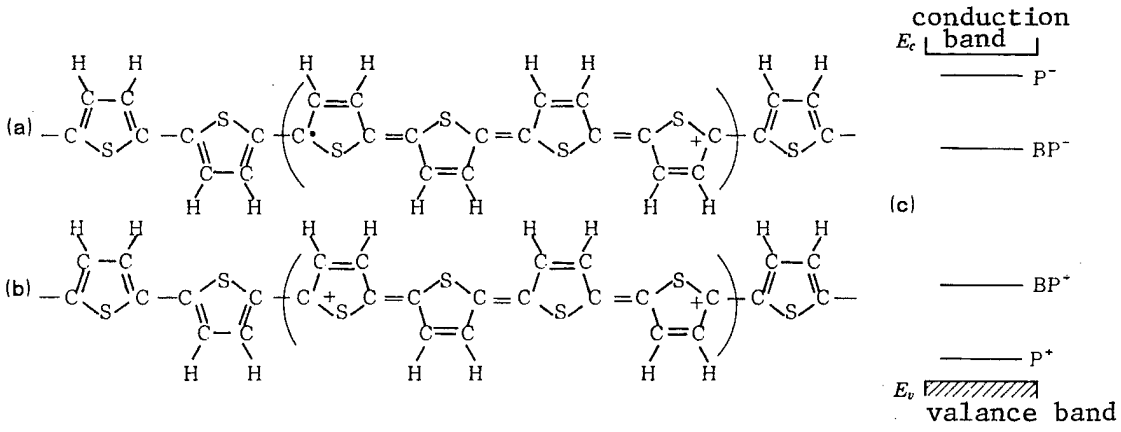


Figure 2. Polythiophene (a) Polaron; (b) Bipolaron (a similar state is seen also with polyparaphenylene); (c) Energy levels of polaron (P^-, P^+) and bipolaron (BP^-, BP^+); the energy of P^- and P^+ varies according to the presence/absence of dopants in their vicinity; formation of polaron or bipolaron results in increase in E_C (the energy at lower end of the conduction band) and decrease in E_V (the energy at the upper end of the valence band).

electrons and holes are formed in these polymers as is the case with inorganic semiconductors. However, there is a large difference between conducting polymers and inorganic semiconductors. In conducting polymers, the electrons and holes excited by light cause a large distortion in the conjugated system of main chains. This is a characteristic of materials in a primary system. Following this distortion, the energy of the electrons and holes changes, resulting in a kind of localization. This state is called polaron in the case of polyparaphenylene, polypyrrole, polythiophene, etc., in which the ground state is a nondegeneracy system. Polaron contributes to electric conduction.[17,18] There are two types of polaron, positive and negative. Figure 2(a) shows a polaron in polythiophene. Coexistence of many polarons leads to interactions among polarons, resulting in formation of a bipolaron (Figure 2(b)). If an ideally large amount of excitation occurs, polaron bands are formed, bringing about a situation similar to the one observed after a change in the width of the prohibitive band. However, it does not seem to be easy to bring about this situation by means of light excitation. As shown in Figure 2(c), which represents the case of polythiophene, both polaron and bipolaron are located within the prohibitive bandwidth.

On the other hand, in the case of polyacetylene whose ground state is degeneracy, soliton and charged soliton are formed (Figure 3).[19]

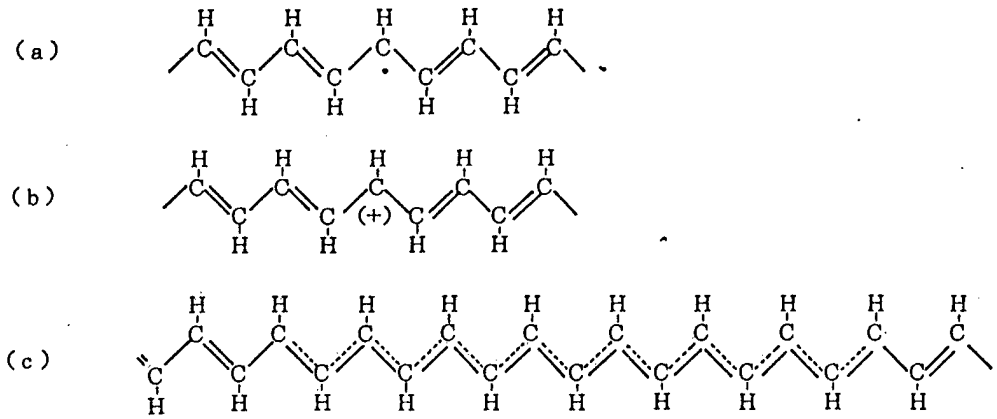


Figure 3. Polyacetylene of Trans Type (a) Soliton; (b) Charged soliton; (c) Actual spatial distribution

The electrons, poles, polaron, bipolaron, soliton, etc. thus formed arrive at the interface between a conducting polymer and a solution, resulting in reaction initiation. Polaron, soliton, etc. have an energy level within the prohibitive bandwidth and can be chemically called radicals. Therefore, they are regarded as highly useful in improving the efficiency of reactions. This is the very reason why the authors took notice of conducting polymers.

In the case of polyparaphenylene, which is the main theme of discussion in this paper, a polaron is formed.

3. Methods of Preparing Catalyst Samples

Taking examples of ZnS powder and polyparaphenylene, the authors will explain how to prepare the semiconductors for use as photocatalysts and conducting polymer catalysts.

3.1. Preparation of Zinc Sulfide Catalyst

Zinc sulfides can be classified into sphalerite of the tetragonal system, wurtzite of the hexagonal system and noncalcined sol. Zinc sulfide of the hexagonal or tetragonal system can be decomposed by ultraviolet light in the presence of water, thereby producing H_2, while noncalcined sol is decomposed by light more slowly. Among these three types of zinc sulfide, noncalcined sol shows the greatest activity as a photocatalyst. ZnS sol, which is obtained, for example, by precipitation from a mixture of 0.1 mol aqueous solution of zinc sulfide and 0.1 mol sodium sulfide, can be directly used as a photocatalyst. Powdered AnS has a very small diameter of ca. 100 Å; its surface area is 140 m^2/g as determined with the BET technique.

The catalytic activity varies greatly depending on precipitation methods; namely, the catalytic activity is delicately changed by the surface condition. For example, when sol is transformed into powder by filtration, the activity is maintained longer if sodium sulfide is not removed. The commercially available high-purity fine grain of ZnS (sphalerite) also has a high catalytic activity, while the activity is quite small in the case of a commercially available AnS having an oxidized surface (ZnO) or electro-light-emitting ZnS which contains a very small quantity of metal. As stated in the paragraph of basic features, charge separation at the semiconductor surface is greatly affected by the surface condition.

3.2. Production of Polyparaphenylene

Polymerization of conducting polymers takes place by a chemical reaction employing ordinary catalysts or by reactions involving heat, light, electrochemical processes, and so on. In recent years, various devices (such as introduction of electrochemical methods) have been made to obtain filmy materials which are more favorable from the standpoint of giving electroconductivity to materials and adapting such electroconductive materials for practical uses. However, from the standpoint of utilizing such materials as catalysts, the powder form is more favorable because of larger surface area; hence, for use as catalysts, the orthodox method is more suitable. Here, the authors will describe the process of producing polyparaphenylene according to the Yamamoto, et al., method.[20]

Grignard reagent was prepared from p-dibrombenzene, magnesium, and dry THF. After completion of the Grignard reaction, the reaction system was cooled to 0°C; then, adding carefully synthesized $NiCl_2$ (bpy), the reaction system was gradually returned to room temperature. At about 25°C, polymerization was initiated and completed in a very short time (several minutes). The material obtained from such a rapid, intense reaction proved to be more effective as a catalyst. Polyparaphenylene powder in ethanol was washed with dilute

hydrochloric acid to remove the Grignard reagent and transition metals; then, after drying in a vacuum state, polyparaphenylene which is insoluble in hot toluene was obtained by a Soxhlet's extractor with the use of toluene. The polyparaphenylene obtained was used as a test sample.

Analysis of the absorption spectrum and the mass spectrum disclosed that the chief product was a polymer which has bromide in the terminal, and that the degree of polymerization can be controlled to some extent by changing the quantity of $NiCl_2$ (bpy). Judging from the very large surface area evaluated by the BET method and from the electron microscopic findings, polymer polyparaphenylene is regarded as fairly polyporous.

4. Photooxidation and Photoreduction on Semiconductor Surfaces

Now, briefly the chemical reactions which are caused by the separation of electrons and holes on the surface of semiconductors.

The electrons which are produced by light on semiconductor surfaces travel to the surrounding molecules and reduce them. At the same time, the active points, called positive holes, deprive the surrounding molecules of electrons and oxidize them. Although the separated electrons and positive holes sometimes rebind, they usually oxidize and reduce the surrounding molecules at the same time. When oxidation and reduction are endothermic reactions and cannot be accomplished thermodynamically without the help of light, we call them photosynthetic reactions, which means that solar energy is stored chemically. In the forthcoming paragraphs, photoreduction and photooxidation occurring on the surface of zinc sulfide semiconductors will be described.

4.1. Production of Hydrogen by Reduction of Water

The first highlighted photochemical reduction using a semiconductor was the production of hydrogen through the reduction of water. For the purpose of promoting photochemical reduction on semiconductor surfaces and suppressing photolysis of semiconductors themselves, catalysts are employed whose surface is decorated with noble metals such as platinum and RuO_2. In the case of ZnS, however, hydrogen production can occur efficiently without the decoration of noble metals.

Reaction settings follow. A solution containing 5 mmol of ZnS sol is added to methanol, tetrahydrofuran, etc., to yield a 400 ml aqueous solution (50 v/v percent). This solution is put into the equipment shown in Figure 4. After deoxidation of this solution, ultraviolet light (wavelength above 290 nm) from a 300 W high-pressure mercury lamp is applied to the solution, resulting in the production of hydrogen at a rate of ca. 40 ml/hour. The hydrogen produced can be captured on the water; further, we can observe bubbles of hydrogen rising from AnS particles. It was confirmed that this hydrogen production is not an outcome of decomposition of the catalyst used for the following reasons: 1) no zinc ion was produced in this reaction; 2) hydrogen production was markedly reduced when water was extremely deficient; and 3) hydrogen was produced when heavy water was used.

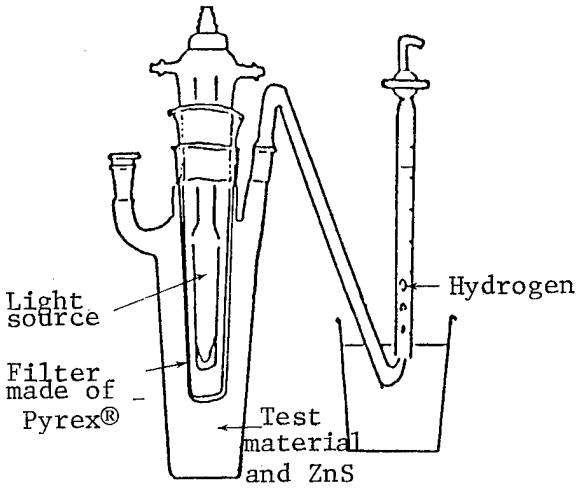


Figure 4. Equipment for Photoreduction of Water Into Hydrogen

In a photocatalytic reaction involving TiO_2/Pt, some investigators report that methanol was oxidized into CO_2 via formaldehyde and formic acid. In a photocatalytic reaction involving ZnS, however, only a small amount of CO_2 was produced. Assuming that two photons produce one hydrogen molecule, we calculated the apparent quantum yield of hydrogen production with 313 nm-light; the yield was 0.15 for methanol, 0.14 for tetrahydrofuran and 0.27 for triethylamine. In the case of tetrahydrofuran, the quantum yield of hydrogen at optimum conditions (i.e., in a boric acid buffer) was 0.62.[21] Recently, the reaction details of producing hydrogen from water using nitrite ions as electron donors were unveiled; in this study, the quantum yield was 0.9.[22]

Why does ZnS work by itself as such an excellent photocatalyst? Henglein and Reber, et al., attribute the excellent property of ZnS to the catalytic action of zinc clusters which are produced during irradiation to zinc sulfide. This explanation, however, is difficult to accept because the hydrogen overvoltage of zinc metal itself is as large as that of mercury. Figure 5 shows the structure of energy bands of TiO_2, CdS, and ZnS which have been studied as photocatalysts. Since the potential of the conduction band of ZnS is largely negative, indicating a strong reduction potential, we speculate that two-electron reduction leads to the formation of a hydride or an active form such as Zn-H.

4.2. Photochemical Reduction of Organic Substrates

Examples of photoreduction of organic substances at the surface of semiconductors are few. The only known examples are one-electron reduction of methyviologen into a cation radical (Formula 1) and reduction of diazo-compounds into hydrazine (Formula 2) which were confirmed by spectrum analysis.

From the finding that diethylamine was efficiently produced by using ZnS as a photocatalyst, the authors discovered that the Schiff's base, which is produced midway in the reaction, is made into alkylamine by two-electron

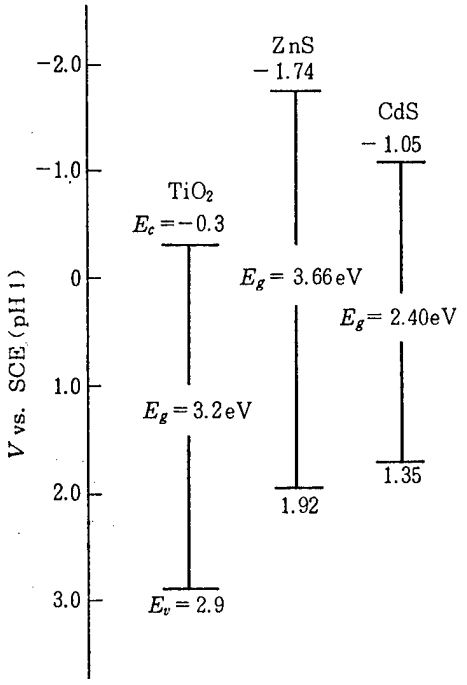
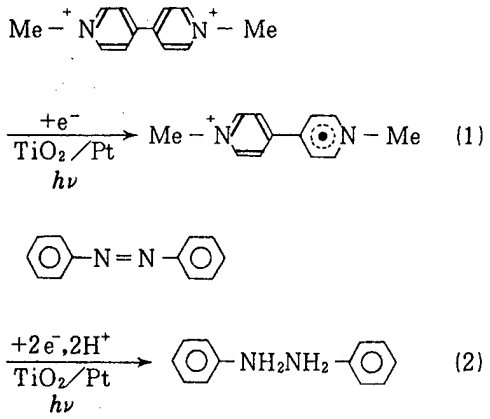


Figure 5. Energy Structure and Interband Gap for Titanium Oxide, Zinc Sulfide, and Cadmium Sulfide



reduction. As shown in Figure 6, irradiation of ethylamine solution in the presence of ZnS sol leads to limited production of hydrogen, but efficient production of diethylamine. During this reaction, formation of ammonium was noted. When acetaldehyde, which is produced by two-electron oxidation of ethylamine was added, production of hydrogen lessened and production of diethylamine increased (Figure 6). When propionaldehyde was added instead of acetaldehyde, ethylpropylamine was produced and no production of diethylamine was observed even 10 hours later.

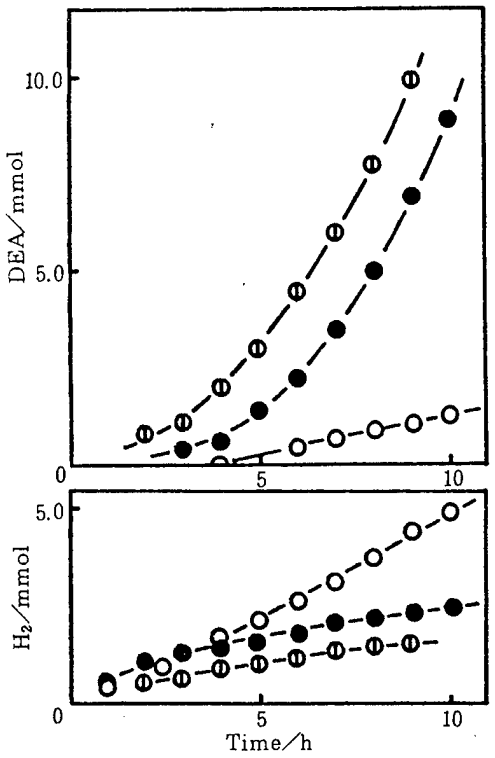


Figure 6. Time Course of Hydrogen and Diethylamine Formation From Ethylamine With the Use of Zinc Sulfide (5 mmol) Serving as a Photocatalyst

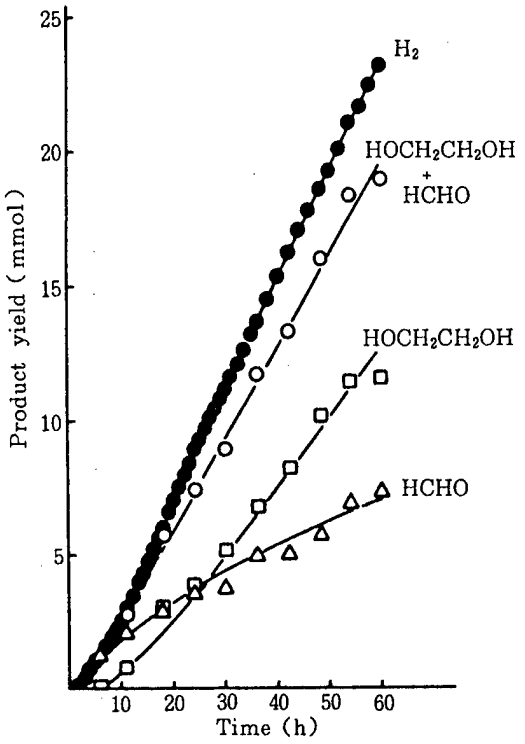


Figure 7. Time Course of Products From Interband-Gap-Light-Excitation of a Solution Containing 2 mmol Zinc Sulfide Sol, 300 ml Methanol and 100 ml Water

These results indicate that Schiif's base, which was made from ethylamine and aldehyde, was photochemically catalyzed on the ZnS surface (Formulas 3 and 4).

$$CH_3CH_2NH_2 + RCHO \xrightarrow{-H_2O} CH_3CH_2N=CHR \qquad (3)$$

$$CH_3CH_2N=CHR \xrightarrow[ZnS\,/\,h\nu]{2e^-,\ 2H^+} CH_3CH_2NHCH_2R \qquad (4)$$

$$R = CH_3,\ CH_3CH_2$$

The above findings indicate that two-electron reduction was efficiently accomplished by light at the semiconductor's surface in water. If we take into consideration the fact that one photon can cause the movement of only one electron, the above finding suggests that semiconductors themselves are capable of pooling electrons.

4.3. Other Photochemical Reductions

The possibility of photochemical reduction of CO_2 and N_2 on the semiconductor's surface has been studied. However, past studies indicate that the productivity of such a reaction is small and the lifespan of the catalyst is short. Therefore, future studies are indicated. Henglein, et al., reported on the reduction of CO_2 into formic acid with the use of ZnS as a catalyst, saying that the quantum yield of formic acid was 0.3 in the presence of isopropanol.[21] This finding could not be confirmed by followup studies of the authors and the research group of the Institute of Molecular Science. However, from the theory of energy, it is possible to achieve this quantum yield. So, additional detailed studies should be made.

4.4. Formation of C-C Bond by One-Electron Photochemical Oxidation

The energy of the valence band of ZnS is not very large when compared with that of TiO_2 (Figure 5). Therefore, it is likely that oxidation occurs fairly selectively when ZnS is used.

When used as an electron donor, methanol has reportedly been oxidized into CO_2 in the presence of TiO_2 (catalyst). In the presence of ZnS (catalyst), methanol is transformed into formaldehyde and ethylene glycol. Figure 7 shows the formation process of hydrogen, formaldehyde and ethylene glycol when light of 290 nm or longer wavelength from a 300 W mercury lamp is applied to 300 ml of methanol, 100 ml of water and 2 mmol of ZnS.

Currently, ethylene glycol is produced from methanol by the following processes: 1) gamma ray irradiation to methanol leads to the formation of CH_3O radical; 2) adjoining methanol molecules are deprived of methyl proton and given $HOCH_2$ radical; and 3) addition polymerization of these methanol molecules leads to the formation of ethylene glycol. The CH_3O radical and $HOCH_2$ radical which are formed by one-electron oxidation are thought to contribute to the formation of ethylene glycol with the use of a semiconductor ZnS (Formulas 5 and 6).

$$CH_3OH \xrightarrow{-e^-} (CH_3OH)^+\cdot \rightarrow CH_3O\cdot \xrightarrow{CH_3OH} HOCH_2\cdot \quad (-H^+) \qquad (5)$$

$$2HOCH_2\cdot \longrightarrow HOCH_2CH_2OH \qquad (6)$$

In addition, if each radical undergoes one-electron oxidation, formaldehyde is formed (Formulas 7 and 8).

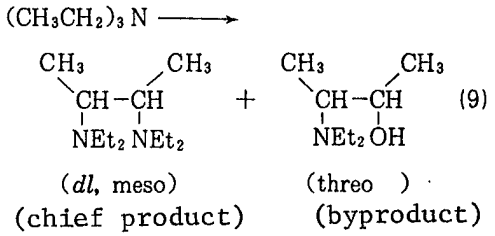
$$CH_3O\cdot \xrightarrow{-e^-} CH_3O^+ \rightarrow HCHO + H^+ \qquad (7)$$

$$HOCH_2\cdot \xrightarrow{-e^-} HOCH_2^+ \xrightarrow{OH^-} HOCH_2OH \xrightarrow{-H_2O} HCHO \qquad (8)$$

The above processes suggest that formaldehyde contributes to the formation of ethylene glycol; namely, it is likely that an addition reaction $HOCH_2$ to formaldehyde with the subsequent reformation of $HOCH_2$ radical through one-electron reduction of aldehyde occurs. If the water content of the reaction system is increased, two-electron oxidation of methanol takes place preferentially, allowing selective formation of aldehyde. When ethanol or 2-propanol is used instead of methanol, a similar product of one-electron oxidation (diol) as well as products of two-electron oxidation (acetaldehyde and acetone) are obtained.

As a system in which the carbon-carbon bond forming reaction occurs selectively, we can cite a photocatalytic reaction of 50 v/v percent solution of triethylamine.

As shown in Formula 9, the chief product of this reaction is a dimer diamine (a mixture of equal amounts of dl and meso). At the same time, however, amino alcohol is also produced, suggesting the role of acetaldehyde formed by two-electron oxidation.

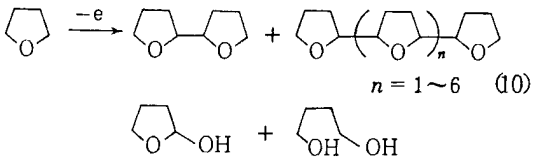


All of these products are new compounds. It is noteworthy that these compounds, which were difficult to synthesize in the past, can be synthesized by a one-step reaction using this method.

4.5. Oligomerization

When tetrahydrofuran, which is easily oxidated, was irradiated with light in the presence of ZnS sol, selective formation of 2,2'-vitetrahydrofuryl (having a coupling between alpha-carbons) occurred; at the same time, 2-hydroxytetrahydrofuran (a product of two-electron oxidation) and 1,4-butanediol (possibly a product of reduction of 2-hydroxytetrahydrofuran) were produced in very small quantities. However, the quantities of these products were about half that of the hydrogen produced; hence, the electrons involved in oxidation and reduction did not make ends meet. In a detailed analysis, it was revealed that the formation of a substantially large quantity of oligomer which cannot be detected by gas chromatography was formed.

To be noted, when less quantity of tetrahydrofuran was used, oligomer became a chief product and the percentage of dimer fell to about 10 percent of total products. This finding can be explained as follows: the dimer, first formed, was preferentially absorbed into ZnS, where it underwent a one-electron oxidative coupling reaction (Formula 10).



Analysis of the mass spectrum disclosed that the molecular weight of the oligomer was between the molecular weight of trimer and that of octamer.

The fact that the photochemical reactions on the semiconductor grain surface in water resulted in efficient hydrogen production and carbon-carbon bond formation means that the photosynthetic reaction, i.e., conversion of solar energy into chemical energy was achieved through a very simple procedure. Further, these reactions are quite interesting in evaluating the relationship between light and chemical evolution.

5. Reduction of Water Into Hydrogen With Conducting Polymers Serving as Photocatalysts

Into a quartz-made optical cell having a three-way stop cock, 5 mg of polyparaphenylene (a dodecamer), 1-2 ml of water and 2-3 ml of an organic substrate were added; after irradiation with ultraviolet light (wavelength 313 nm or 366 nm), the volume of hydrogen produced was determined. As shown in Table 1, hydrogen generation occurred at wavelengths of 313 and 366 nm. When irradiation was made in the absence of polyparaphenylene, no hydrogen generation occurred. Comparison among various electron donors disclosed that amines, which are easily oxidized, show good results, while no hydrogen was generated when hexane, dihydrofuran, etc., were used as electron donors.

Table 1. Hydrogen Generation

Organic electron donor	Water (ml)	PPP (mg)	Wavelength (nm)	Duration of irradiation (分)	Quantum yield ϕ ($1/2\,H_2$)
Diethylamine (3 ml)	1	10	313	1172	0.034
Diethylamine (3 ml)	1	10	366	240	0.006
Diethylamine (3 ml)	1	10	>400	125	≒0
Triethylamine (2 ml)	2	10	313	200	0.008
Triethylamine (2 ml)	2	10	366	240	0.005
Methanol (3 ml)	1	15	313	240	0.0004

Quantum yield was calculated on the assumption that one hydrogen molecule is generated by two photons.

Figure 8 shows the time course of hydrogen generation when 313 nm-light was irradiated in the presence of diethylamine (an organic substrate). For comparison, the data with the use of a commercially available ZnS microcrystal (sphalerite) are also shown in the same figure.

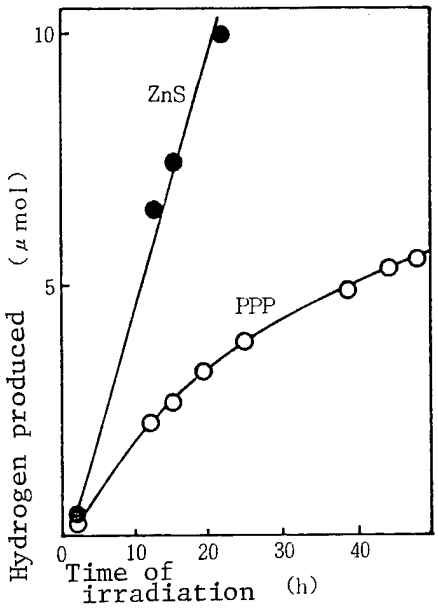


Figure 8. Time Course of Hydrogen Generation From Water With the Use of Polyparaphenylene Serving as a Photocatalyst

Although the efficiency was smaller than with ZnS, the use of polyparaphenylene proved to cause a long-time generation of hydrogen. In the case of photocatalytic reaction using heavy water (D_2O) instead of water and involving triethylamine as an electron donor, we obtained a gas volume ratio of D_2: DH : H_2 or D = 36 : 5 : 2, which indicates that D_2 was a chief product. This result indicates that the source of hydrogen was water rather than triethylamine or polyparaphenylene, and that the water was reduced by light.

Toluene-soluble polyparaphenylenes from hexamers or those with a similar degree of polymerization have no catalytic activity, while those from dodecamers proved to have catalytic action. Polyparaphenylenes with a higher degree of polymerization (e.g., nonadecamer) tended to show better results, indicating that the photocatalytic activity becomes larger with growing degree of polymerization. As stated in the beginning, polaron is thought to be present in four or more benzene rings assuming that it is formed after excitation by light. Therefore, the necessity of a fairly high degree of polymerization is endorsed also from the viewpoint of polaron formation. Further, taking into consideration that the formed polaron, etc. interfaces with the solution by diffusion or other movement and that polaron etc. become more mobile with the growing degree of polymerization, it is understandable that a higher degree of polymerization is preferable for achieving high efficiency. The same can also be said about soliton.

When triethylamine was used, some products of two-electron oxidation were detected by gas chromatography, although isolation or identification of these products was not allowed because of the poor efficiency of this reaction compared to the reaction using ZnS.

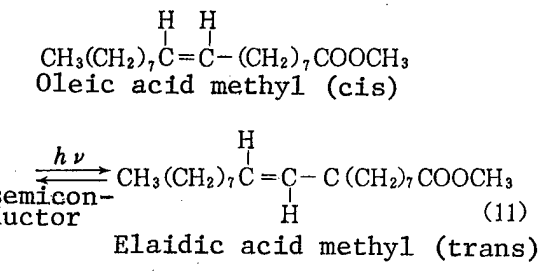
At present, the authors are studying the photocatalytic action of many conducting polymers such as polynaphthalenes and polythiophene.

6. Catalytic Action of Semiconductors and Conducting Polymers in Cis-Trans Photoisomerization

Studies involving cis-trans isomerization of carbon-carbon double bonds under irradiation with light have been conducted by many investigators using aromatic compounds and ketones which serve as triple state sensitizers. As a possible mechanism of such a reaction, the intermediates involved mechanism is known, which is manifested in energy transfer, electron transfer, exciplex formation, radical addition, or radical elimination. With any of the possible mechanisms, semiconductors after irradiation are expected to be useful in photoisomerization reactions. In the past, reports were made about photoisomerization of 2-butene in a gas phase with the use of oxidized semiconductors such as TiO_2 and ZnO. However, no study has ever been tried using liquid-phase isomerization of semiconductors from the olefin family.

For the purpose of developing a new reaction system to isomerize elaidic acid ester (a byproduct of reduction of fats and fatty oils) into oleic acid ester, the authors studied and reported photoisomerization of oleic acid methyl and elaidic acid methyl using semiconductors as photocatalysts.[13]

A 2 ml methanol solution containing 0.04 mol of methyl oleic acid (cis) or elaidic acid ester (trans) was added to 0.02 mmol of TiO_2, CdS or ZnS; then, while being magnetically stirred, the solution was irradiated with a light of 290 nm or longer wavelength to result in highly effective isomerization in the presence of CdS or ZnS (no isomerization in the presence of TiO_2). In the presence of ZnS, the cis/trans ratio in an optical stationary state was 0.20 (the percentage of cis being 17 percent), while in the presence of CdS (Formula 11), the ratio was 0.44 (the percentage of cis being 31 percent).



No isomerization was observed in the presence of TiO_2, ZnO or $SrTiO_3$.

The reaction proceeded quite cleanly, without showing any decrease in substrates or any production of byproducts which were likely to occur in a reaction involving electron transfer. Based on these results, we proposed the energy transfer mechanism.[23] However, we now regard the radical mechanism, involving a localized energy level, as a more reasonable mechanism to explain the above reaction on grounds of the following findings obtained in a recent study[24]: 1) The cis/trans ratio in the above reaction is equal to the

cis/trans ratio in a state of thermal equilibrium achieved with the use of diphenylsulfide; 2) the deactivation rate in the above reaction is smaller than that in the acetophenone sensitizing reaction which is proceeded by energy transfer; and 3) the quantum yield obtained suggests the presence of a chain reaction.

When polyparaphenylene and polyparaphenylenesulfide were used as catalysts, isomerization was observed, thereby recording cis/trans ratios of 0.22 and 0.20, respectively, in an optical stationary state.

The above catalytic action in cis-trans isomerization is thought to be accounted for by the localized energy level at the semiconductor surface and in the presence of a radical such as polaron. We are proceeding with this research.

7. Conclusion

In the above, the authors briefly described various photochemical reactions we have been studying such as hydrogen production and photoisomerization reactions with the use of semiconductor particles and conducting polymers serving as photocatalysts. We believe the readers can understand the high efficiency of these reactions. As stated in the beginning of this article, utilization of solar energy is one of the most effective means for solving the issues of energy, resources, and environment. Furthermore, this photochemical method is also applicable to other uses such as decomposition of materials whose natural decomposition is difficult. Therefore, more will be expected of this technique from now on, and we should put it into practical use at any cost.

At present, the authors are focusing on: photocatalytic reactions in the visible light range, localized (superficial) energy levels of semiconductor particles, localized state of polaron, etc. of conducting polymers, and the essence and role of radical behavior.

FOOTNOTES

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MARKET TREND OF OPTICAL DISK DISCUSSED

Tokyo OPTRONICS in Japanese Nov 85 pp 60-64

[Article by Yoshinobu Mihashi, chief, Optoelectronics Research Room, Electrotechnical Laboratory, Agency of Industrial Science and Technology and Masao Kato, Development Division, Optoelectronic Industry and Technology Development Association (OITDA)]

[Excerpt] Market Trend of Optical Disk Products

Market trends of optical disk products will be outlined below. All such disk items made their appearance in the market only in recent years and business has been rather limited. Thus, information available for market predictions of these items has been insufficient and the figures so far reported in the predictions are quite different. In observing reported market predictions of optical disk products, materials from surveys which such predicted figures are based on should be carefully reviewed.

7.1 Predicted Production of DAD/CD and Optical VD

The Optoelectronic Industry and Technology Development Association (OITDA) conducted a survey on the transitional shifts of production and demand for various kinds of optical disk players. The survey results are indicated in the graphs below: Figure 38 shows how the domestic production scale of optical disk players has changed, and Figure 39 shows the transitional change of domestic demand for them in recent years. It is noted that these indicated indexes are limited to domestic demand and do not include overseas demand.

As seen from these figures, the compact disk (CD) players made their appearance in 1982. It made a very rapid growth. In 1983, their market expanded to 10 times their original market size. Since that year, demand for such products has continued to double every year. It is anticipated that domestic demand for CD players will increase to about five million units in 1989. The market size of such products in the United States and European countries alike in 1990 is predicted to be double that of Japan. Being ahead of CD manufacturers in other countries, Japanese CD manufacturers are busy expanding their overseas markets as well as their domestic market. In attempting to expand the CD market, the first consideration should be establishing of system to provide software for CD utilization.

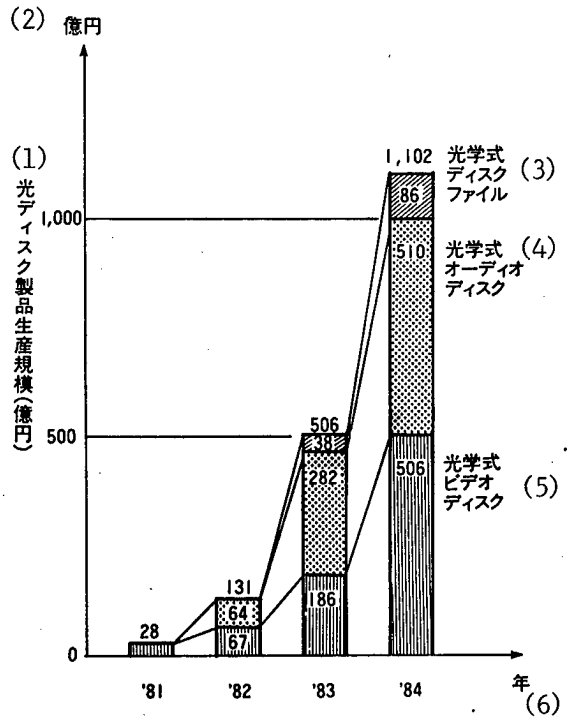


Figure 38. Change in Domestic Production Size of Optical Disk Players

Key:

1. Size of optical disk production (in Y100 million)
2. (In Y100 million)
3. Optical disk file
4. Optical audio disk
5. Optical video disk
6. Year

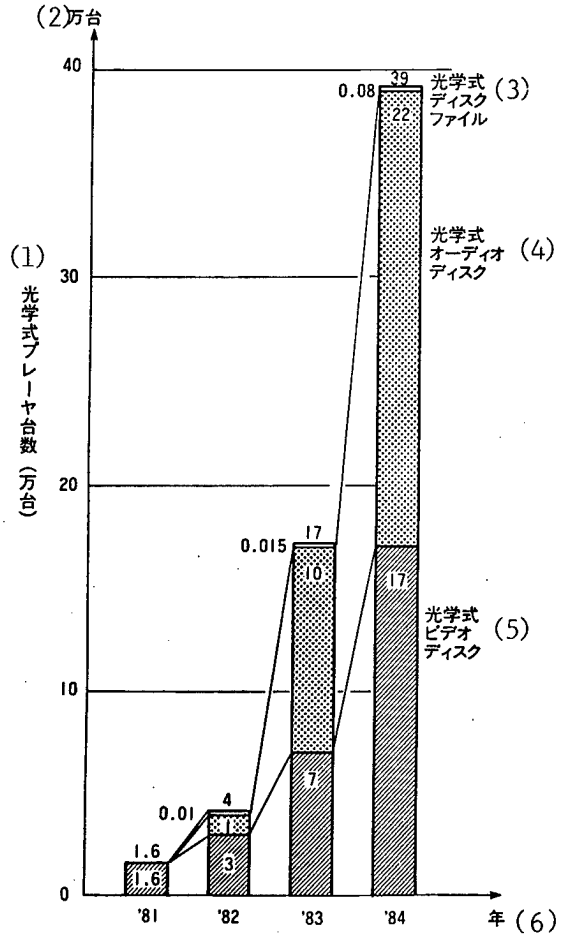


Figure 39. Change in Domestic Demand for Optical Disk Players

Key:

1. Demand for optical disk players (in 10,000 units)
2. (In 10,000 units)
3. Optical disk file
4. Optical audio disk
5. Optical video disk
6. Year

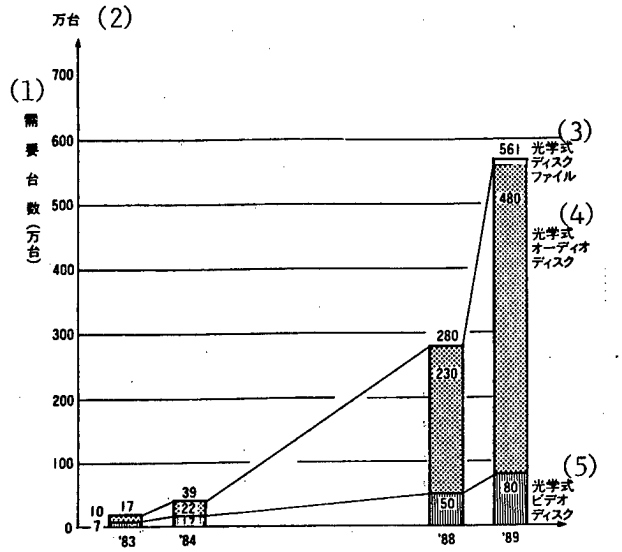


Figure 40. Estimated Domestic Demand for Optical Disk Players

Key:

1. Estimated player demand (in 10,000 units)
2. (In 10,000 units)
3. Optical disk file
4. Optical audio disk
5. Optical video disk

The optical video disk player was put on the market earlier than the compact disk. Despite the market emergence of the video disk player preceding the CD, domestic share ratio of the video disk to the CD became reversed in 1984; this is because the CD business grew with astonishing speed. While trying to compete in the market, the optical VD is unavoidably affected by various factors such as keen rivalry with the VTR and the non-optical VHD. Nevertheless, the optical VD will certainly find a market of a size no smaller than the CD market. The general opinion is that, in the future, the optical disk will have a dominant share of the market.

In the overseas markets for the optical VD, the European market is more developed than the U.S. market. RCA of the United States withdrew from the business of the non-optical CED (capacitance electric disk). Due to stagnation of the disk business in the United States as the "after-effect" of the RCA withdrawal from the disk market, the optical VD market will probably grow after several years. Development of optical VD software requires by far more complicated work with more costs than development of CD software. For this reason, it is unlikely that the optical VD will make the rapid growth that the CD has made.

The optical VD, however, is expected to make steady progress, because there will be many uses of it to which its random access function is indispensable.

7.2 Market Trend of OD^3

As shown in Figures 38 to 40, the OD^3 (optical digital data disk), including the document file disk has a market of a rather limited size. It is, however, anticipated that after 10 years, much more OD^3 will be in use in OA (office automation) systems, memory units within personal computers and external memory units within computers, and thus its market will be greater in size than the CD or VD market. Figure 41 shows presumed price ratio of the magnetic disk to other devices contained in various computer systems. More and more optical disks are expected to be used in computers, taking the place of magnetic disks. Table 17 shows specification of optical disk units in which OD^3 is used. Referring to the table, the very low end disks less than 130 mm ϕ are intended for use in personal computers or in office automation systems. The early low end disks 130 mm to 300 mm ϕ and the mid range disks 200 mm to 300 mm ϕ will be used in document file units or business computers. And the high end disks of 356 mm ϕ is for large-sized computers or MSS (mass storage systems). Figure 42 shows an index of money amount of such optical disks expected to be shipped. These figures are based on a survey by Freeman Associates Inc. Because the very low end 130 mm ϕ disk is usable as an alternative to the floppy disk, its market is expected to rapidly expand around 1988. The predicted size of optical disk market in Japan, Europe, and the United States is anticipated to be approximately in the ratio of 1 : 1 : 8.

World shipment of optical disks is expected to reach Y1 trillion in 1989 and Y2 trillion in 1990.

With the anticipated growth of the optical disk market, the price of its medium materials is predicted to fall as the index in Figure 44 shows.

8. Standardization of Optical Disks

The field of information equipment and devices have become noticeably influenced by the trends of their international standardization. Optical disks are no exception. So, standardization of optical disks must be based on understanding of the international standardization situations for them. Optical disk standardization today has some aspects which must be carried out in anticipation of technological trends. For development of optical disk products, a thorough grasp of trends of their standardization is required.

8.1 Standardization System for DAD/CD and VD

The system for DAD/CD standardization is shown in Table 18.

For DAD/CD, the International Electrotechnical Commission (IEC) is working on international standardization. The commission's TC60/SC60A/WG17 are particularly in charge of international standardization of CD. In Japan, in response to draft international standards of DAD/CD proposed by the commission, the Special Committee on Audio Recording of Acoustics Society of Japan handles the draft. As for proposed draft specifications of such products for Japan Industrial Standards (JIS), the CD Players Working Group of the Audio Technology Committee of Electronic Industries Association of Japan is in charge of the proposed draft specifications.

Then, the propulsion system for video disk standardization is shown in Table 19. For video disk international standardization, TC60/SC60B/WG8 of the International Electrotechnical Commission is acting to propose draft video disk international specifications. The commission's draft international specifications of this product proposed are treated by the Audio Recording Survey Committee of Television Society of Japan. As for proposed specifications of video disks for JIS, the Video Engineering Committee of Electronic Industries Association of Japan treats the proposed specifications of the products. This committee also treats proposed standardization purpose specifications of optical laser disks (LD) and non-optical video high frequency disks (VHD).

8.2 Standardization of OD^3

Table 20 shows the OD standardization propulsion system. For the purpose of propelling OD^3 standardization on international level, SC 23 (Subcommittee 23, i.e. OD Subcommittee was formed, in May 1984, under TC97 (Technical Committee 97, i.e. Technical Committee on Computers and Data Processing) of the International Standard Organization (ISO). Japan was chosen as secretarial member-nation of that subcommittee. From May 29 through 31, 1985, the first session of the subcommittee's international conference was held in the hall building of Japan Society for the Promotion of Machine Industry (JSPMI) in Tokyo. Junichi Shimada (chief, Radiowave and Electronic Division of Electrotechnical Laboratory) was appointed chairman of that conference. This is a sign that Japan's OD^3 engineering level and practical use of it in

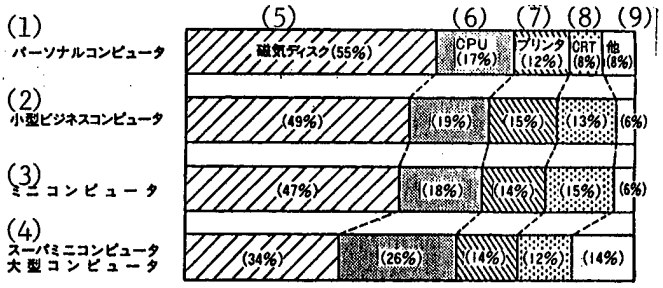


Figure 41. Magnetic Disk Price Ratio to Other Devices in Computer System Presumed for 1987 (as based on mini-micro systems November 1984)

Key:

1. Personal computer
2. Small business computer
3. Mini computer
4. Super mini computer and large computer
5. Magnetic disk
6. CPU
7. Printer
8. CRT
9. Other devices

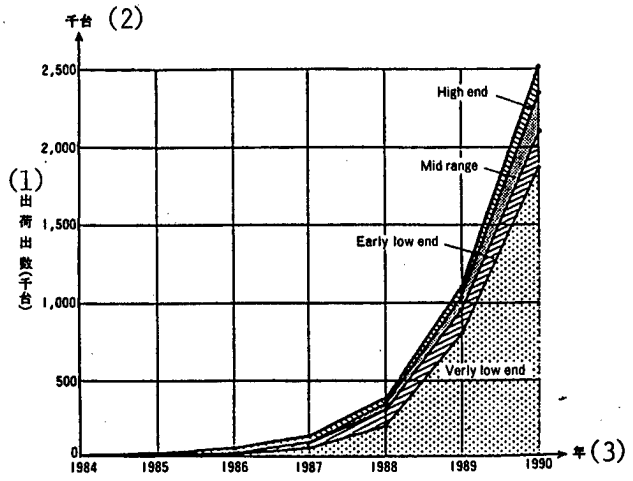


Figure 42. Change in Optical Disk Shipment

Key:

1. Optical disk shipment (in thousands)
2. (In thousands)
3. Year

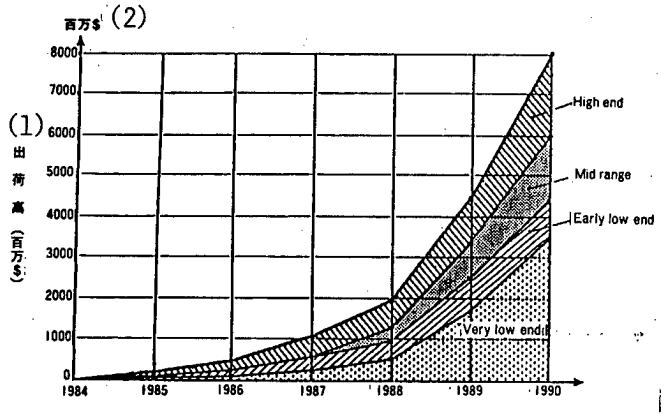


Figure 43. Change in Amount of Optical Disk Shipment

Key:

1. Amount of shipment (in $1 million)
2. (In $1 million)

(1)	(2)	(3)	(4)	(5)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Very low end	130mm以下 (7)	0.1~0.5GByte／面(6)	0.1~1MByte／s	200ms 以下 (7)
Early low end	300, 200mm, 130mm	0.5~2GByte／面 (6)	0.3~2MByte／s	100~500ms
Mid range	300mm, 200mm	2~4GByte／面 (6)	1~3MByte／s	200ms 以下 (7)
High end	356mm	4GByte／面 (6)	3MByte／s	100ms 以下 (7)

Table 17. Specifications for Application to Optical Disk Units

Key:

1. Scope of performance
2. Disk diameter
3. Disk capacity
4. Transmission speed
5. Access time
6. Per face (side)
7. Below

manufacturing such products are more advanced than other countries of the world. Proposals the subcommittee of ISO gives are to be treated by the TC97/SC23 Japan Committee in Information Processing Society of Japan.

Proposed OD specifications for JIS are to be treated by OITDA entrusted with OD^3 draft specifications treatment by the Agency of Industrial Science and Technology. In order to give support to the standardization authority, OITDA, in September 1985, caused makers to form a "optical disk manufacturers assembly" having 91 member manufacturers.

Besides ISO, some foreign organizations are working actively at OD^3 standardization: They are X3B11 committee of American National Standard Institute (ANSI) and TC31 committee of European Computer Manufacturers Association (ECMA). Japanese manufacturers are actively cooperating with these foreign agencies in OD^3 standardization activities.

Regarding OD^3 standardization, ECMA proposed that the standardization be proceeded, with disk size being classified into four size categories: Below 130 mm ϕ , 200 mm ϕ , 300 mm ϕ , 356 mm ϕ . SC23 committee decided to follow such proposal. In the first session of SC23 world conference held in Tokyo, the issue of standardization of the disk size category "Below 130 mm ϕ " was brought up for discussion, for the reason that standardization of this category is of the greatest urgency of all the four categories; this category is of "low cost very low end."

Points in dispute in the conference were as follows:

(1) Cartridge thickness. (Coordination of 12 mm thickness of air-incident type by 3M Corp. of the United States and 9 to 11 mm thickness of disks by Japanese and European manufacturers.)

(2) Shape of disk track. (Claimed inclusion of non-pregrooved and concentric types by U.S. manufacturers, in addition to spiral-pregrooved type by Japanese and European manufacturers.)

Matters concerning environmental specifications for testing, operation, preservation, and transportation, etc. Previously it was decided that the first DP (Draft Proposal) would be made up in the ad hoc editing group meeting to be held in Amsterdam in October 1960.

The second SC23 world conference is scheduled to be held 23-25 September 1986 in Geneva, and its third world conference scheduled to be held in the United States in 1987.

In Japan the optical disk standardization committee for dealing draft OD^3 specifications for JIS was appointed in July 1985 at the request of Agency of Industrial Science and Technology, MITI. The tasks assigned to the committee are:

(1) Studies on exchangeability of various kinds of optical disks.

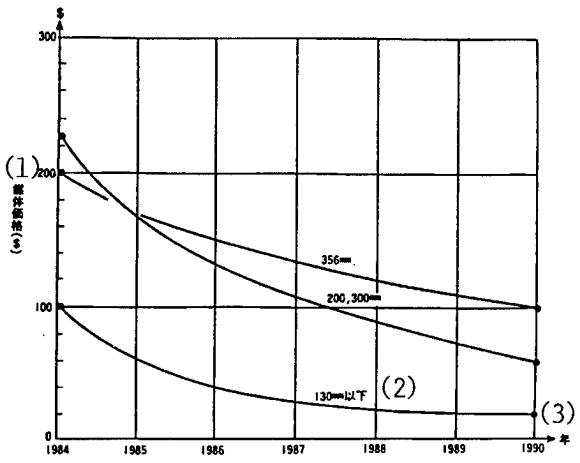


Figure 44. Change in Medium Material Prices

Key:

1. Medium material price in dollars
2. Below 130 mm
3. Year

(1) (2)

	(3) IEC 対応	(4) JIS 素案対応
IEC TC60 (Recording) SC60A (Sound recording) WG17 (CD)	(5)㈳日本音響学会 (7)録音専門委員会 (委員長 トリオ㈱ 松岡常務取締役)	EIAJ (6)㈳日本電子機械工業会) (8) オーディオ技術委員会 CD プレーヤワーキンググループ (9)

Table 18. System for Propulsion of Standardization of DAD/CD

Key:

1. International
2. Japanese
3. Work flow to respond to IEC specifications proposed
4. Work flow to respond to JIS specifications proposed
5. Acoustic Society of Japan (literal, Nippon Onkyo Gakkai)
6. Electronic Industries Association of Japan
7. (Recording Special Committee
   Chairman: Managing Director Matsuo, Trio Corp.)
8. Audio Technical Committee
9. Player Working Group

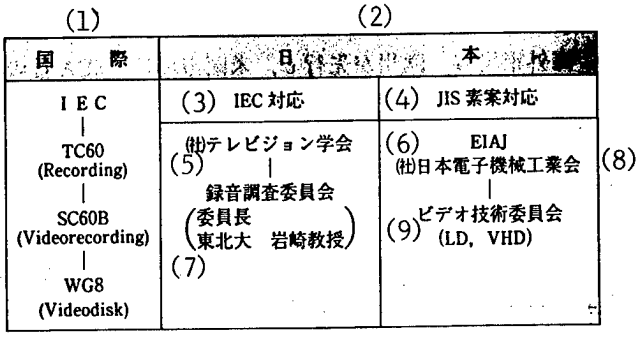


Table 19. System for Propulsion of Standardization of Video Disks

Key:

1. International
2. Japanese
3. Work flow to respond to IEC specifications proposed
4. Work flow to respond to JIS specifications proposed
5. Institute of Television Engineers of Japan
6. EIAJ
7. (Recording Techniques Survey Committee (literal)
   Chairman: Professor Iwasaki, Tohoku University)
8. Electronic Industries Association of Japan
9. Video Technical Committee

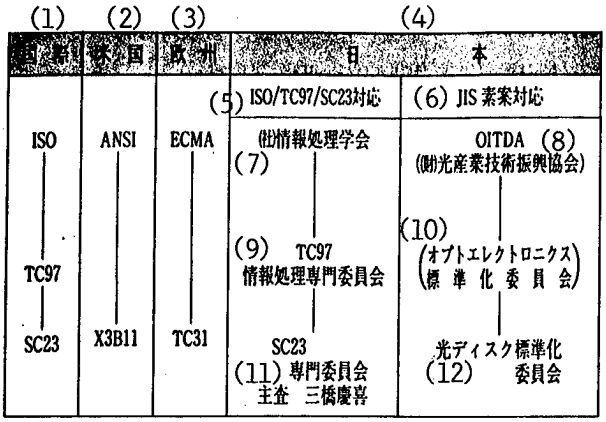


Table 20. System for Standardization Propulsion of OD[3]

Key:

1. International
2. United States
3. Europe
4. Japan
5. Work flow to respond to ISO/TC97/SC23 specifications
6. Work flow to respond to JIS specifications proposed
7. Information Processing Society of Japan
8. OITDA (Optoelectronic Industry and Technology Development Association
9. TC97 Information Processing Technology Special Committee
10. Optoelectronic Standardization Committee
11. SC23 Special Committee
    (Chief: Yoshinobu Mihashi)
12. Optical Disk Standardization Committee

(2) Standardization of "Write-Once" type optical disks (specifying mechanical characteristics, optical characteristics, drive mechanism, system mechanism, testing procedures, and assessment processes, etc.)

(3) Research on standardization of "Erasable" type optical disks.

(4) Studies on testing procedures of disk medium materials.

Authors' Note

The writers have given a description of the basics and prospects of optical disks in a wide scope from the fundamental matters to development issues. In the description, the writers are afraid, the excellence of optical disks may have been emphasized rather too much, thus less importance may seem to have been attached to rival products such as magnetic memories (floppy disk, magnetic disk, magnetic tape, etc.).

However, magnetic memories, and the like actually have unique attractive features which optical disks do not possess. So, it is important to recognize that, even if optical disks having outstanding features enter the disk market, they and magnetic disks would certainly be able to coexist, and that, even if they should substantially take the place of magnetic disks in the market, they would not be able to do so for some time.

The rewriting optical disks will most probably be realized of all uncompleted optical disks. This type, however, has no great market possibility, so it is necessary to find beforehand some market for that type.

Optical disks are fascinating, because they have great possibilities and subjects left to be achieved. It is desirable that, now and after, undeveloped aspects of optical disks will be uncovered and new subjects posed one after another.

20,142/9599
CSO: 4306/1530

JDA GUIDELINES FOR 1987 OPERATIONAL PLANS REPORTED

Tokyo AEROSPACE JAPAN in English Jul 86 pp 72-73

[Text]

The Japanese Defense Agency (JDA) announced on May 16 the guidelines for the three services of the Self-Defense Forces and the Technical Research and Development Institute (TR&DI) to work out their respective operation plans for the next fiscal year to begin April 1, 1987.

Going into the second year of the FY'84 Mid-Term Defense Program (the so-called "59 Chugyo"), the guidelines call for stable progress of the program and at the same time giving consideration to difficult financial affairs.

In a breakdown by major item, first of all, the Ground Self-Defense Force (GSDF) is required to procure newly the Medium MAT antitank missile and procure continuously the AH-1S and CH-47J helicopters and the Heavy MAT antitank missiles. The GSDF is also required to reorganize the 2nd and the 7th Division Headquarters in Hokkaido and to procure necessary equipment and facilities associated with reorganization of the 5th and the 11th Division Headquarters.

As for the Maritime Self-Defense Force (MSDF), the guidelines call for continuous procurement of the P-3C antisubmarine patrol planes, HSS-2B helicopters and the CIWS (close-in weapon system), plus construction of a deepwater MSC.

Concerning the Air Self-Defense Force (ASDF), the guidelines require continuous procurement of the F-15 fighter interceptors and procurement of the Patriot missile for the second fire unit. Procurement of the last lot of the new BADGE system is also included with a view to beginning the operation in 1988. As for the FS-X next support fighter program and the full-scale production of the remodeled F-4EJ, the guidelines do not touch much upon them, just calling for necessary measures. These two projects are subject to the National Defense Council after examination inside the JDA, according to the guidelines.

As for the activities related to command communications, intelligence and electronic warfare, the IDDN (Integrated Defense Digital Network) program will be started, while radars and other ECM systems will be either newly procured or improved.

The HH-X new rescue helicopter program of the ASDF is not itemized specifically under the guidelines but it is featured as part of the requirements of improved transport capability and various other support systems.

/13046
CSO: 4307/15

NO EARLY DECISION ON FS-X EXPECTED

Tokyo JPE AVIATION REPORT-WEEKLY in English 28 Jul 86 pp 2-3

[Text]

The Air Self-Sefense Force (ASDF) is scheduled to submit its survey report on the McDonnell Douglas F-18, General Dynamics F-16 and the Panavia Tornado aircraft to Gen. Hitoshi Omura, Chief of Air Staff, within August. The three aircraft are listed as foreign candidates of the FS-X next-phase support fighter to replace the Mitsubishi F-1 presently in service with the Japanese air force.

Domestic development, local production of foreign aircraft under license and a modification of the McDonnell Douglas F-4EJ (in service with ASDF) are considered as possible choice for the FS-X.

In the latter part of last year, ASDF sent questionnaires through diplomatic channels to the manufacturers of the three foreign aircraft manufacturers concerning operational data, possibility of Japanese production under license, lead time required for such license production and other technical details. ASDF received answers from the manufacturers through diplomatic channels in early February.

In order to clarify some details and to obtain additional data and information, ASDF dispatched in May Maj. Gen. Hiroshi Hosho (present Director, Defense Operations Div., Air Staff Office), accompanied by three field-grade officers to the three manufacturers, related engine and avionics firms as well as government agencies concerned. ASDF has apparently obtained all the data and information it wanted.

The possibility to produce any of these three foreign aircraft under license or to import complete aircraft now appears to be almost nil. All of them are found to be excellent front-line fighter aircraft in service, but they may not be able to be operational through the next century, sources say. Moreover, they have been developed to meet specific requirements of the operating nations, and their requirements are not necessarily same as those of Japan.

As for domestic development possibility, both the defense authorities and the Japanese aircraft industry agree that Japan would be able to design, develop and produce the FS-S, judging from its technological levels of the aerospace and electronics industries. (The engine for the FS-X will have to be either imported or produced here under license.) They also maintain that development of a new military aircraft will certainly help solidify the basic foundation of Japan's defense capabilities.

The military and trade relations between Japan and the United States cannot, however, be ignored. American manufacturers are reportedly pushing hard for joint development of the FS-X. Seiki Nishihiro, Director-General of JDA's Defense Bureau, told a National Diet session early this year that international joint development of the FS-X can be interpreted as one of the domestic development forms JDA has in mind, indicating that participation of American manufacturers in the Japanese development of the FS-X is a possibility. In this case, McDonnell Douglas is considered the most likely American participant, observers predict.

A final decision on the FS-X is expected to be made by the Cabinet in or after December, 1986, after deliberations and approval by the National Security Council (former National Defense Council). This will, however, have to be preceded by screening procedures at JDA and the council, which normally takes a few months to complete.

/13046
CSO: 4307/20

KEIDANREN CALLS FOR DOMESTIC DEVELOPMENT OF FS-X

Tokyo JPE AVIATION REPORT-WEEKLY in English 28 Jul 86 p 4

[Text]

Masao Kanamori, vice chairman of the powerful Federation of Economic Organizations (Keidanren), strongly called for domestic development and production of the Air Self Defense Force's (ASDF) FS-X next-generation support fighter.

Meeting the press last week, Kanamori, also chairman of Keidanren's Defense Production Committee and MHI chairman, said, "We should manufacture and operate weapons and repair them on our own in order to maintain a high performance and cut down costs." He thus indicated that Keidanren will urge the government to proceed with domestic development of the FS-X, which will replace the F-1 fighter now in service.

The Japanese Defense Agency (JDA) has been inclined on adoption of a "quasi domestic production" method for the FS-X program, under which Japanese aircraft manufacturers will virtually take the initiative in the development, while allowing U.S. aircraft firms to take part in some aspects of it.

Kanamori showed confidence that Japan has sufficient technical capability to develop a new support fighter aircraft. He also disclosed Keidanren's plan to ask the government to boost appropriations for defense research and development, including those for the FS-X program, in the FY 1987 budget. He added that the government should attach importance to the defense budget from long-term viewpoints wihtout being affected in changes in economic trends.

Meanwhile, Kanamori showed Keidanren's positive stance toward Japanese participation in the research phase of the U.S. Strategic Defense Initiative (SDI). He said that the Japanese private sector should join the SDI program on condition that the sophisticated technologies that would be secured by the Japanese participants could be utilized for commercial purposes one way or another.

/13046
CSO: 4307/20

XSH SLATED TO BEGIN SERVICE IN FY91

Tokyo JPE AVIATION REPORT-WEEKLY in English 28 Jul 86 p 5

[Text]

Development of the XSH-60J new antisubmarine helicopter is progressing on schedule. It is slated to make its first flight at the end of September, 1987.

A variant of the Sikorsky SH-60B Sea Hawk helicopter, the XSH-60J is being developed by Mitsubishi Heavy Industries, Ltd. (MHI) under contract from JDA's Technical R&D Institute (TR&DI). It is designed to be operated from DD destroyers of the Maritime Self-Defense Force (MSDF).

After ground-based flight tests, the first XSH-60J is scheduled to be tested aboard the 3,400-ton 58-DD (funded in FY 1983) which is being constructed at IHI's 2nd Tokyo Works. The destroyer will be launched in the fall of 1987.

The first XSH-60J will be delivered to MSDF in June 1989, preceded by the delivery of the second aircraft which will take place two months earlier (April 1989). The two helicopters will be assigned to the 51st MSDF Flight Sq. at Atsugi Base, Kanagawa Prefecture, for operational tests.

Equipped with the helicopter combat direction system (HCDS), automatic flight management system (AFMS) and other advanced avionics, the XSH-60 will have far more superior antisub capabilities than the Sikorsky HSS-2B now in service with MSDF.

MSDF plans to begin procurement of the new antisub helicopter in FY 1988, the third year of the present five-year Medium-Term Defense Buildup Program (MDBP). uring the period of the MDBP, it plans to secure funding for 15 each of the shipborne and the land-based Sikorsky HSS-2B and 36 SH-60s. Deployment of the SH-60J to front-line units will begin in FY 1991, according to present planning.

/13046
CSO: 4307/20

BRIEFS

HH-X SELECTION NEARING--The Japanese Air Self-Defense Force (JASDF) is now progressing with the HH-X program to introduce a new long-range and all-weather type rescue helicopter as a replacement of the Kawasaki/Vertol KV-107A helicopters currently in service. The HH-X candidates include the modified version of Sikorsky SH-60J (HH-60J), Kawasaki V-107X, Aerospatiale AS332 Super Puma and Bell 214ST. With a view to starting introduction of the HH-X in FY'87, the JASDF hopes to settle on the new helicopter as early as possible but the selection work seems to be meeting with a difficulty. The most likely choice is said to be the Sikorsky SH-60J (a version of the U.S. Navy's Sikorsky SH-60B fitted for operation in Japan) which the Japanese Maritime Self-Defense Force (JMSDF) has already decided to introduce. The high unit cost, which was regarded as the stumbling block to select the SH-60J, has been lowered to about Y2,500 million (US$13,150,000) per aircraft, according to a proposal recently made by Mitsubishi Heavy Industries Ltd. On the other hand, the Aerospatiale AS 332L Super Puma, proposed jointly by Sony Trading Corp. and Fuji Heavy Industries Ltd. is given a high value on its maritime operation in the North Sea off England as well as in France. Introduction of new rescue helicopters is now planned by the JASDF. However, since the JMSDF is also expected to need rescue helicopters in the near future, the HH-60J has definite advantages in terms of unifying the type of the helicopters for the two services. But the JASDF's Air Rescue Wing (stationed in Iruma Air Base) favors a tilt-rotor wing aircraft like the Bell/Boeing V-22 as an ideal rescue aircraft in the future. Even more, if the HH-60J should be purchased at this moment, there would be no chance to buy new ones over the next 15 years or so. Therefore, the JASDF might as well continue procurement of the present KV-107A helicopters in three to four years more and then adopt the V-22, although the KV-107A leaves somewhat to be desired. [Text] [Tokyo AEROSPACE JAPAN in English Apr 86 p 68] /13046

QUESTIONABLE FS-X PROGRAM--The Japanese Air Self-Defense Force (JASDF) is now progressing with the FS-X program to replace Mitsubishi F-1 support fighters. The candidate fighters being studied for the FS-X are General Dynamics F-16C, McDonnell Douglas F/A-18, Panavia Tornado and a domestic fighter. However, the Japanese Defense Agency seems to believe that the three foreign fighters (F-16, F-18 and Tornado) are not capable enough for the FS-X to be deployed in the latter half of the 1990s. The agency hopes to realize domestic FS-X development with the Japanese aircraft technology with Mitsubishi Heavy Industries Ltd. as the central figure. Seemingly, the agency is making a

comparison between domestic development and introduction of foreign fighters. To promote domestic development, the agency is concerned most about political pressure from Europe or the U.S. to buy the Tornado, F-16 or F-18 fighters. To avoid such a situation, the agency hopes to carry forward the FS-X program quietly. But while declaring the foreign fighters as the FS-X candidates, the agency on the other hand is pushing steadily onto the domestic development. There are many who criticize such an underhand way of the agency. Should the domestic development be adopted, the agency will then select the engine to power the FS-X. The candidates include General Electric F404, Pratt & Whitney PW1120 and Turbo-Union Rb.199. Among the three candidates, the agency seems to prefer the F404. The PW1120 has a technical interest but Japan hesitate to adopt this engine because the U.S. Air Force has not adopted it. It would be the RB.199 that competes with the F404. [Text] [Tokyo AEROSPACE JAPAN in English Apr 86 p 68] /13046

CSO: 4307/16

AGENCY UNVEILS NEW SOLAR POWER SYSTEM

OW161351 Tokyo KYODO in English 1151 GMT 16 Jul 86

[Text] Shizuoka, 16 Jul (KYODO)--A government agency has developed a novel power generating system using a solar energy device as a main power source and supplementing it with a log-burning generator on rainy days.

The system, developed by the New Energy Development Organization (NEDO), was displayed to the press Wednesday at a training center operated by the municipal government of Misakubo-Cho, Shizuoka Prefecture, west of Tokyo, where it is installed.

Its main power source is a 5-kilowatt generator consisting of 96 solar cell panels, each 120 centimeters long and 40 centimeters wide. The panels convert sunlight into electricity.

A battery stores electricity derived from the solar system, supplying 15-20 percent of power for lighting at the Natural Club Center, NEDO officials said.

When electricity stored in the battery [is used up] on rainy days, a backup generator powered by steam, using logs as a fuel source, is put into operation automatically, the officials said.

The system was developed in a 90 million yen project undertaken by NEDO as part of a "sunshine program" of the Ministry of International Trade and Industry (MITI). The program is aimed at developing new energy sources.

NEDO, a MITI affiliate, plans to operate the system for 2 years to collect data for commercial application, the officials said.

/9604
CSO: 4307/013

TITANIUM, SHAPE MEMORY ALLOYS FOR AUTOMOBILE SPRING REPORTED

Tokyo KINO ZAIRYO in Japanese Sep 85 pp 34-41

[Article by Shinichi Nagakubo, manager of Technical Division, Murata Hatsujo Co., Ltd.]

[Text] 1. Introduction

An increase in the design stress of an automobile spring has been demanded because of several needs such as low fuel consumption, small size and light weight, and high performance. In order to correspond to these demands, an increase in strength and an improvement in quality have been made of the materials for the spring.

In addition, studies have been carried out for designing and manufacturing of springs, and the fruit of the studies has been seen. Regarding spring design, the analytical technology has progressed, and the optimum design for the form of a spring and the shape of a cross section of materials has been introduced. For instance, many new manufacturing processes represented by the surface hardening method are presently in use.

2. Motivation of Development

There has been a drastic improvement in quality and an increase in strength of the present materials being used. In particular, the development of new materials, such as polymeric materials, composite materials, fine ceramics, and new metals like amorphous, is now being heavily conducted. There is an expectation of the appliation of these materials to the automobile spring.

Among these new materials, we are attempting to study the application of a titanium alloy and shape memory alloy to automobile springs.

2.1. Titanium Alloy

A titanium alloy is a material which has excellent properties in terms of relative strength and corrosion resistance. This alloy has been utilized only in the airplane industry. However, judging from the recent development trend of titanium alloy and the increase of social needs for low fuel consumption and high performance, it can be considered that the use of this alloy will increase in the near future. Because of these circumstances, the development of the application of a titanium alloy for automobile springs is presently being carried out.

2.2. Shape Memory Alloy

A shape memory alloy has the nature such that after it is plastically deformed by deformation force, it is restored to its original shape of no plastic deformation when it is heated. There are lots of possibilities in the utilization of the characteristic of restoring to an original shape and previous temperature, and of the force generated during the restoring process.

An automobile can provide the necessary energy source for the utilization of a shape memory alloy. Thus, an automobile is a suitable place for the application of this material. In addition, since it is possible to make high performance and compact automobile parts by utilizing the sensor function and the actuator function of this alloy, its application to springs for an automobile can be expected.

3. Spring Materials for an Automobile

As the functions of a spring, the following is pointed out:

--Relation between applied load and deformation;
--Absorption of accumulation of elastic energy;
--Isolation of vibration and relaxation of shock.

On the other hand, a high elastic limitation is required for metallic materials for springs. Furthermore, fatigue resistance, heat resistance, corrosion resistance, nonmagnetism, and electric conductivity are also required depending on application conditions. Materials having these properties already exist. Steel materials and nonferrous metals, for instance, are some of those. Availability and ability to be processed are also very important factors.

Table 1[1] shows the typical steel materials generally used for automobile springs.

4. Titanium Alloy Coil Spring

4.1. Titanium Alloy

Titanium has three distinctive features, i.e., light weight, strong, and rust free. A titanium alloy makes the most of these features. There are three basic types as a practical alloy.

They are α type, $\alpha + \beta$ type, and β type. Typical examples of titanium alloys are shown in Table 2. Among these alloys, 6Al-4V alloy of the $\alpha + \beta$ type is primarily in use. The spring for an automobile made of this material has already been developed. However, an alloy of the β type is superior to that of the $\alpha + \beta$ type in strength and processing. Since the β type alloy is a cubic crystal, it shows superiority in cold working when compared with the α type alloy of a hexahedral crystal. Among titanium alloys, the one that shows maximum tensile strength is obtained from the β type alloy. Therefore, this alloy is expected to be utilized in springs in the future.

Table 1. Standards of Steel Materials for Springs

	Standard number	Name	Symbol
Hot coiled helical springs	JIS G 4801	Spring steels	C steel: SUP3, SUP4 Si-Mn steel: SUP6, SUP7 Mn-Cr steel: SUP9, SUP9A Cr-V steel: SUP10 Mn-Cr-B steel: SUP11A
Wire springs	JIS G 3521	Hard drawn steel wires	SW
	JIS G 3522	Piano wires	SWP
	JIS G 3560	Oil tempered carbon steel wire for mechanical springs	SWO
	JIS G 3561	Oil tempered carbon steel wire for valve springs	SWO-V
	JIS G 3565	Oil tempered chromium-vanadium alloy steel wire for valve springs	SWOCV-V
	JIS G 3566	Oil tempered silicon-chromium alloy steel wire for valve springs	SWOSC-V
	JIS G 3567	Oil tempered silicon-manganese alloy steel spring wires	SWOSM
	JIS G 4314	Stainless steel wire for springs	SUS-WP
Thin leaf springs	JIS G 3311	Cold rolled special steel strip	M
	JIS G 4802	Cold rolled steel strip for springs	CSP
	JIS G 4313	Cold rolled stainless steel strip for springs	SUS-CSP

4.2. Titanium Alloy Spring Materials

When a titanium alloy is considered as a spring material, the following distinctive features can be pointed out:

--High relative strength;
--Low shear modulus;
--Excellent corrosion resistance;
--Large logarithmic damping ratio[4];
--Other excellent characteristics (thermal resistance, nonmagnetism).

If this material is used for automobile springs by utilizing these features, their application to an engine valve spring can also be considered. In addition, because of light weight and compactness, the application to a suspension spring and other springs may be possible also.

Especially in the case of application to a valve spring, making it light weight and compact, the increase of natural frequency, and the decrease of

Table 2. Titanium and Its Alloy

Type	Alloy composition	Heat treatment	Tensile strength (kgf/mm^2)	Remarks
	Industrially pure titanium	Annealing or cold working	25 - 50	Excellent welding
α type or semi-type	5Al-2.5Sn	Annealing	87	Good welding
	8Al-1V-1Mo	"	112	" "
	7Al-12Zr	"	116	" "
	2.25Al-11Sn-5Zr-0.2Si	"	112	(England) High strength at high temperature
	6Al-2Sn-4Zr-6Mo	STA	120	(United States) Good tempering
α + β type	6Al-4V	Annealing	95	Wide application
		STA	120	Extension material, casting material
	4Al-3Mo-1V	STA	136	Extension material, bad welding
	4Al-4Mo-2Sn-0.5Si	STA	125	(England)
	6Al-2Sn-2Zr-2Cr-2Mo-0.25Si		130	(United States) Good tempering
	5Al-4.5V-2Mo-1Cr-0.6Fe	STA	185-200	(Soviet) Trial, no toughness
	6Al-6V-2Sn-6Zr-(Cu, Fe)	STA	133	(France) Trial
	8Al-4Co	STA	134	(Japan) Trial
β type	13V-11Cr-3Al	STA	160	(United States)
	11Cr-8Mo-3Al	STA	148	(Soviet Union)
	15Mo-5Zr-3Al	STA	150	(Japan) Toughness
	11.5Mo-6Zr-4.5Sn	STA	119	Beta III, good processing (United States)
	3Al-8V-6Cr-4Zr-4Mo	STA	126	Beta C, good tempering (United States)

STA Solution Treated + Aging

the surging loading stress can be expected. The other characteristics of the material can also be fully utilized.

4.3. Design Example of Titanium Alloy Spring

The specific gravity of titanium alloy is about 60 percent that of piano wire. It is expected that the strength of titanium alloy is equivalent or superior to that of piano wire. If springs with the same shape and dimensions are each made by titanium alloy and piano wire, the titanium alloy-made spring is lighter than the piano wire-made one by about 40 percent. Table 3 shows the material properties of titanium alloy and piano wire of the V class.

Table 3. Properties of Titanium Alloy and V Class Piano Wire

Materials \ Properties	Tensile strength kgf/mm^2	E kgf/mm^2	G kgf/mm^2	Specific gravity g/cm	Remarks
Titanium alloy ϕ 2.0	200	10,000	4,000	4.85	After aging process
S W P V ϕ 2.0	180-195	21,000	8,000	7.85	

In the case of which the same spring characteristic is considered, since the shear modulus of titanium alloy is about half that of piano wire, the number of active coils of the titanium alloy-made spring becomes half compared with that of the piano wire-made one. Furthermore, a reduction in the weight of the spring with the number of coil reduced by 40 percent can be expected. There is a totally drastic reduction in the weight of the titanium alloy-made spring.

Table 4 shows a comparison between the springs made by titanium alloy and V class piano wire under the condition of the same allowable stress. An example of the springs trial-manufactured based on the specification described in Table 4 is shown in Figure 1. In this example, the number of active coil of the titanium alloy spring is 3.5 times less than that of the piano wire spring. The specific gravity of the titanium alloy spring is about 40 percent less than that of the piano wire spring. Accordingly, a 62-percent reduction in weight is achieved.

Table 4. Design Examples of Titanium Alloy and V Class Piano Wire

Materials	Titanium alloy	V class piano wire
Wire diameter (mm)	2.0	2.0
Number of total coil	5.5	9.0
Number of active coil	3.5	7.0
Average diameter of coil (mm)	12.0	12.0
Free height (mm)	29.1	36.1
Spring constant (kgf/mm)	1.29	1.3
Solid height (mm)	12.0	17.0
Weight (g)	3.16	8.36

V class piano wire spring Titanium alloy spring

Figure 1. Titanium Alloy Spring and V Class Piano Wire Spring

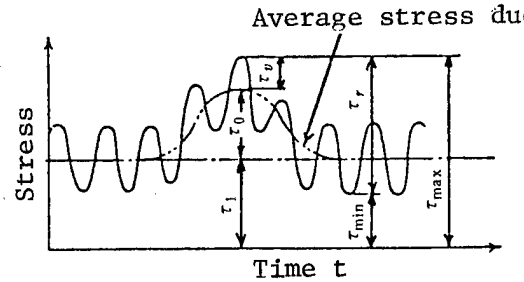
4.4.2. Light Weight and Compact

When looking at the design example shown in Table 4, in the case of springs having the same characteristics, the titanium alloy spring is lighter than the piano wire spring by about 62 percent. Since the number of active coil of the titanium alloy spring becomes 3.5 times less than the conventional one, its solid height becomes 29.4 percent lower.

As can be seen, it is possible to lower solid height as well as to reduce the weight. This means that there are a lot of degrees of freedom in designing. Because of this fact, for the application to a valve spring, it is possible to cope with the increase of valve lift and load under a limited space. In addition, it may end up with a reduction in the engine size.

4.4.3. Vibration Characteristics

When a spring is subjected to forced vibration, a resonance phenomenon called surging occurs in the spring. The increase of stress due to surging becomes a serious problem in the case of a valve spring for an automobile. Figure 2[5] explains the increase of stress due to surging.



τ_0 Static stress corresponding to valve rising
τ_1 Initial compressive stress
τ_r Fluctuation limits of stress
τ_v Maximum value of fluctuated stress

Figure 2. Stress Increase Due to Surging

In order to reduce the spring resonance, several methods are being considered. They are, for instance, to increase the natural frequency of a spring itself, and to put unequal pitches.

When a comparison of the natural frequency of the first mode between the two springs shown in Table 4 is made, equation (1) gives the calculated natural frequency of the first mode.

$$f_i = \frac{d}{2\pi n D^2}\sqrt{gG/2\gamma} \quad (1)$$

where, f_1: natural frequency of the first mode (cps)
d : wire diameter (mm)
D : the number of active coil
G : shear modulus (kgf/mm^2)
γ : weight per unit volume of spring material (kg/mm^3)
g : acceleration of gravity ($9.8 \times 10^3 mm/S^2$)

Table 5 shows a comparison between the results of calculation by equation (1) and the experimental result. According to this, the natural frequency of the titanium alloy spring is 1.6 times higher than that of the piano wire spring. As can be seen, natural frequency becomes higher in the case of the titanium alloy spring. Thus, effectiveness to suppress surging can be expected. Figure 3[6] shows the typical example of a resonance curb obtained by the vibration test of a valve spring. In this example, it is clearly seen that as resonance becomes higher, loading stress due to surging becomes smaller.

Table 5. Comparison of Natural Frequency Between Calculation and Experiment

Materials		Titanium spring	V class piano wire spring
d Wire diameter (mm)		2.0	2.0
n Number of active coil		3.5	7
D average diameter of coil (mm)		12.2	12.1
G Shear modulus (kgf/mm^2)		4,000	8,000
γ Weight per unit volume of spring material (kg/mm^3)		4.85×10^6	7.85×10^6
g Acceleration of gravity (mm/S^2)		9,800	9,800
Natural frequency (CPS)	Calculation	73,962	41,683
	Experiment	68,182	42,553

4.5. Problems of Titanium Alloy Spring

A titanium alloy spring has a lot of excellent features, but at the same time, it also has defects.

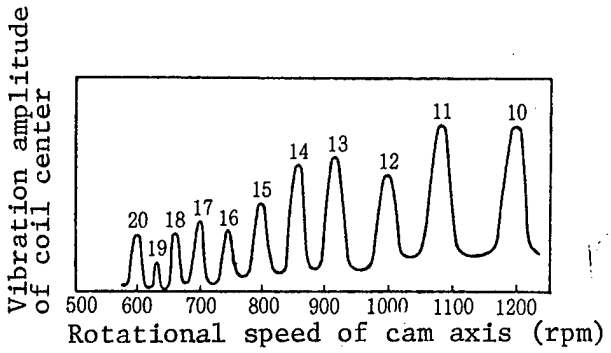


Figure 3. Example of Valve Spring Resonance Curve

4.5.1. Problems Associated With Processing

Surface finishing is a very important process for a titanium alloy spring. During the wire coiling process, a special treatment is necessary in order to prevent the occurrence of a scratch or a cut. Because titanium alloy is a sensitive material, attention should be paid to plating. The occurrence of a scratch or a cut and surface oxidization deteriorate the fatigue strength and characteristics of a titanium alloy spring.

The aging process of titanium alloy requires longer time than that needed for ordinary materials. It is necessary to consider preprocessing and the circumstances of heat treatment.

Regarding grinding of spring ends, because titanium alloy is very difficult to be ground, the selection of a grinding whetstone and speed of grinding become important factors to be considered. Due to low heat conductivity, attention should be made to not overheat.

Shot peening is a very important process. This process has important influence on the fatigue characteristic of a titanium alloy spring. Special consideration should be given to the selection of shot materials, the combination of shot methods, and the conditions of processing by looking at their effectiveness.

As described so far, the study of each processing is necessary and important for a titanium alloy spring.

4.5.2. Spring Shape and Other Problems

When springs having the same characteristics are compared, the number of coil of a titanium alloy spring becomes small. This results in a large pitch angle. Unevenness in size becomes large in processing, and an increase in stress may become a problem in practical application. This means that when a titanium alloy spring is in practical use, a reduction as much as possible in the free height of the spring should be made.

On the other hand, titanium alloy spring material is still in the development stage. There are uncertainties with respect to its cost and availability.

5. Shape Memory Alloy Spring

5.1. Shape Memory Alloy

Shape memory alloy is now in the limelight as a functional material. It is expected to be applied in various fields in the future. There are two features in shape memory alloy. One is shape memory effect, and the other is ultra-elastic effect.

Shape memory effect is the phenomenon of being restored to original shape when heated to the high temperature region (up to austenite phase), after plastic deformation takes place by deformation force at the low temperature region (martensite phase).

Ultra-elastic effect is the phenomenon of when a shape memory alloy is deformed exceeding its yield point, this alloy shows apparent plastic deformation. But when the stress is removed, the strain disappears and it assumes the original shape.

Shape memory is the unique phenomenon seen only for the alloy which has phase transformation called thermal elastic type martensite transformation. Table 6[7] shows alloys having shape memory characteristics. There are many alloys which show the characteristics of shape memory. However, only Ti-Ni alloy and Cu-Al-X alloy can be in practical use.

Table 6. Composition of Various Shape Memory Alloys and Phase Transformation Temperature

Alloy system	Composition (atom percent)	Ms (K) (°C)	As (K) (°C)
Ti-Ni	Ti-50Ni	333 (60)	351 (78)
	Ti-51Ni	243 (-30)	261 (-12)
Ti-Ni-Cu	Ti-20Ni-30Cu	353 (80)	358 (85)
Ti-Ni-Fe	Ti-47Ni-3Fe	183 (-90)	201 (-72)
Cu-Zn	Cu-39.8Zn *	153 (-120)	—
Cu-Zn-Al	Cu-27.5Zn-4.5Al*	168 (-105)	—
	Cu-13.5Zn-8Al*	419 (146)	—
Cu-Al-Ni	Cu-14.5Al-4.4Ni*	133 (-140)	164 (-109)
	Cu-14.1Al-4.2Ni*	270.5 (2.5)	293 (20)
Cu-Au-Zn	Au-21Cu-49Zn	120 (-153)	—
	Au-29Cu-45Zn	330 (57)	—
Cu-Sn	Cu-15.3Sn	232 (-41)	—
Ni-Al	Ni-36.6Al	333±5 (60±5)	—
Ag-Cd	Ag-45.0Cd	199 (-74)	193 (-80)
Au-Cd	Au-47.5Cd	331 (58)	347 (74)
In-Tl	In-21Tl	333 (60)	338 (65)
In-Cd	In-4.4Cd	313 (40)	323 (50)

5.2. Shape Memory Alloy as Materials for Springs

A Ti-Ni alloy and Cu-Al-X alloy have already been put to practical use; the former is more frequently utilized for automobile spring materials. This is because the Ti-Ni alloy is much more superior to the copper base alloy in terms of fatigue characteristics, ease of processing, and restoring capability, although the copper base alloy exhibits cost advantage.

Regarding the Ti-Ni alloy, it is possible to obtain materials having various transformation temperature. If the temperature or size is specified in detail, however, it may not be easy to actually obtain them. In addition, there is no standard for these materials. It is necessary to consult material makers about the selection of the materials. Furthermore, the Ti-Ni alloy is very difficult to handle. The amount of spring back is large, and this makes it difficult to manufacture springs.

5.3. Features and Application of Shape Memory Alloy Spring

A shape memory alloy spring has the following characteristics:

--The relationship between force and deflection shows nonlinear characteristics;

--Due to temperature change, force decreases rapidly during the process of martensite phase transformation, and increases drastically during the reverse phase transformation process;

--There is the existence of hysteresis.

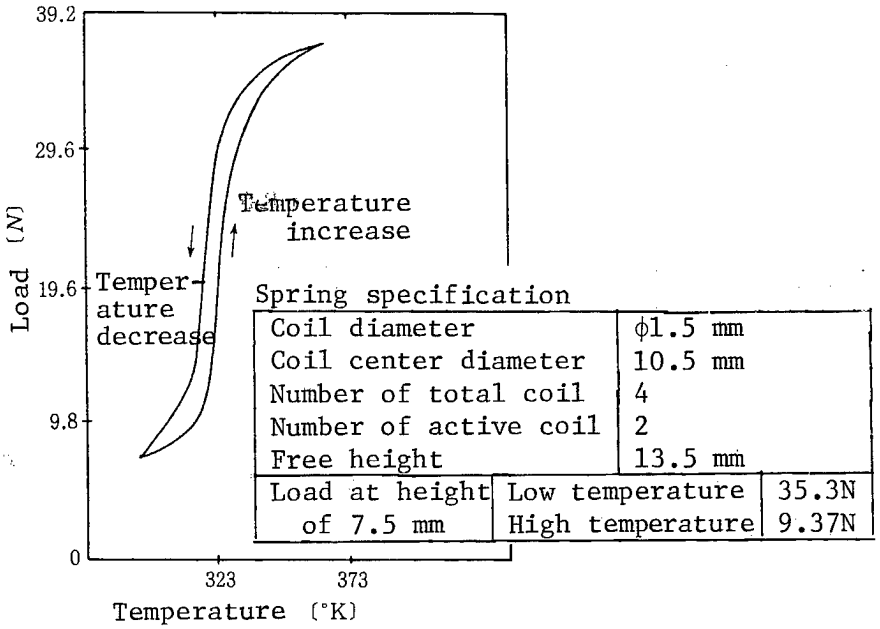
Among the above, because of the second feature, the function as a sensor and an actuator can be expected from this material. In this case, in order to increase operation stroke, there is the application of this material to various coil springs.

This material can also be utilized for automobile springs. Figure 4 shows an example of the shape memory alloy coil spring being manufactured. Its specification and the experimental data of temperature-force characteristics are also indicated in the same figure. In order to improve fuel consumption, this spring acts by sensing a temperature increase, and possesses the mechanism of both a sensor and an actuator, which cuts out unnecessary energy loss.

5.4. Process of Shape Memory Alloy Coil Spring

5.4.1. Process of Compression Coil Spring

A compression coil spring is processed by an automatic coiling machine. However, a Ti-Ni alloy wire has large spring back, and is difficult to process. Unevenness in size and shape is large due to wire curl. In addition, the tool of the coiling machine and the lubrication of the material exert a great influence on processing. Even though coating is placed on the surface of the material, with the increase in processing speed, unevenness in size may become large, and overheating and biting may easily happen.



Spring specification

Coil diameter		ϕ1.5 mm
Coil center diameter		10.5 mm
Number of total coil		4
Number of active coil		2
Free height		13.5 mm
Load at height of 7.5 mm	Low temperature	35.3N
	High temperature	9.37N

Figure 4. Specification of Shape Memory Alloy Spring and Temperature-Load Characteristics

The conditions of shape memory treatment will have a major influence on the thermal and fatigue characteristics. However, it is possible to reduce unevenness in coil size with the application of a device at the treatment procedure.

Since a Ti-Ni alloy is a very difficult material to grind spring ends, and it is very easily deformed after shape memory treatment, the grinding process should be very carefully carried out. The influence of grinding heat on a coil portion should be avoided. Therefore, it may be necessary to establish specification without applying grinding of spring ends.

5.4.2. Process of Tension Coil Spring

A tension coil spring is processed by a microcomputer-aided automatic molding machine. In this case, unevenness in size and hook shape due to wire curl becomes a problem to be solved. During processing, coating as a lubricant film of a wire and lubrication itself become important factors.

Since shape memory treatment is carried out under restraining by a fixture, design of the fixture should be made by considering operational efficiency. Spring shape should be designed so that processing by the automatic molding machine is applicable, there is less unevenness, and the restraint of a fixture is physically easy.

5.5. Problems Associated With Shape Memory Alloy Springs

A shape memory alloy spring has excellent characteristics which cannot be seen in other springs. There are great expectations about its application. However, there are many problems to be solved before it is going to be in general use.

First, regarding materials, it will be a great convenience to have the standard of phase transformation temperature and size for selection from the viewpoint of a user. It is more suitable to have the attached data of each material lot, and corresponding standard shape memory treatment conditions and phase transformation temperature. Because the present material cost is too high, naturally, there is a limitation in its usage.

The great bulk of various data is the designing know-how of each company. In order to increase the utilization of shape memory alloy springs, the establishment of the design method and the preparation of sufficient data are necessary for designers.

There are no major problems in processing a coil spring of a shape memory alloy. Concerning inspection and testing of shape memory alloy springs, exclusive simple equipment for inspection and testing should be prepared, and a general agreement with regard to the evaluation method of a characteristic should also be made.

6. Future Outlook

Although there are problems associated with the cost and the development of a high strength string material from a titanium alloy, its great contribution to light weight, compactness, and high performance can be expected.

Judging from the recent trend of R&D of a titanium alloy, it will not be long before we are able to obtain a material of high strength with relatively low cost. Accordingly, it can be considered that full-scale application of the materials to an automobile will come true.

Many people are aware of a shape memory alloy spring. There is an expectation of its application. Therefore, various kinds of studies have recently taken place. However, at this moment, examples of its practical use are very few. This is due mainly to lack of various data, the existence of difficulty in design, and high cost of materials. Nevertheless, if these problems are solved, a wide application of a shape memory alloy spring may be seen.

FOOTNOTES

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3. As written in the paper.

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5. Spring Technical Research Association, "Spring," Maruzen, 1982, p 213.

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USES OF CERAMICS, METALS, PLASTICS DISCUSSED

Tokyo NIKKO MATERIALS in Japanese Jan 86 pp 26-31

[Text] Ceramics

Isuzu Puts Ceramic Engine to Practical Use, Will Install in Passenger Cars in 1990

Isuzu Motors, Ltd., has put a ceramic engine to practical use in a 1,800 cc and diesel engine and will market passenger cars with ceramic engines in 1990. In respect of elasticity and impact resistance it has been impossible up to now to manufacture ceramic main parts such as head liner, cylinder liner, turbine, camshaft, etc., as well as piston ring and valve. But now, these main parts can be manufactured by using ceramics. Therefore, the rigidity of ceramic engines can be ensured. On the other hand, the cylinder block, etc., were designed so they are made of cast iron, because there was no need to enhance the heat resistance.

The company has performed a road test on a small passenger car equipped with this ceramic engine, ranging over 180,000 km. In addition, this car has traveled a distance of more than 300 km at a speed of more than 120 km/hr. as a result, the company is confident of being able to put such a small passenger car to practical use from the standpoint of distance and speed. Also, the company has effectively used high-temperature exhaust gas as energy by making the best of the high-temperature resistance of ceramic engines. It has also developed a compound engine system based on a motor drive system, and has improved both output and fuel cost by 30 percent over conventional diesel engines.

Refractory and High-Heat Insulating Ceramic Sash

Asahi Glass Co., Ltd., has developed a ceramic sash by using a technology for molding GRC (glass fiber reinforced concrete), and will start putting it on the market as a high-heat insulating sash with pair glass in late 1986. This new sash is made by reinforcing inorganic materials combined by cement, gypsum, and slag, with alkali-resistant glass fibers. It can be extrusion-molded freely. In addition, it possesses the following features: 1) Resin layers are formed on or vinyl resin is applied to the surface so as not to generate the "Lack." 2) The strength in the longitudinal direction is enhanced by simultaneously extruding glass long fibers during the molding work and by

inserting them into the inside. 3) It is possible to cut off, drill, and screw materials at sites, because these materials are comparatively soft. The cross section shape varies from small and large diameters to multilocular hollows.

Ceramic Bearing Enables MC To Carry Out Double-Cutting Work With Ultrahigh Accuracy.

Mitsui Precision Industry Co., Ltd., has developed a horizontal type MC (machining center) called, HS5A" and a vertical type MC called, "VS5A," and has put them on the market. Ceramic bearings are fitted onto the main shaft of these MC's. The MC's can be used for carrying out the double-cutting work with ultrahigh accuracy. The ceramic bearing itself was developed by NTN Toyo Bearing Co., Ltd., in collaboration with Mitsui Precision Industry Co., Ltd. It is an angular ballbearing with ceramic balls. It is designed so it can cope with the Dn value (diameter of spindle x rotation frequency) of more than 1.2 million. The rotation frequency of 15,000 per minute has been realized by using the BT-50 spindle with a diameter of 100 mm. For reference, this rotation frequency is almost twice that of conventional bearings. The features of the new MC's are as follows: 1) The ultrahigh speed rotation can be obtained by adopting ceramic bearings. 2) The accuracy and rigidity are enhanced by using a T-shaped bed. 3) The torque of the main shaft is more than 100 kgm. 4) The double cutting work can be carried out. The maximum working volume is 850- x 700- x 750-mm. The rapid traverse speed is 15 m per minute. The main shaft motor has 15 kw and 20 horsepower. The spindle torque is 103.7 kgm. The price of the HS5A is ¥45 million, and that of the VS5A is ¥35 million.

Very Large CIP Is Delivered to Toyo Carbon Co., Ltd.

IHI (Ishikawajima-Harima Heavy Industries Co., Ltd.) has delivered the world's largest scale CIP (cold isostatic pressing) facility to Tama Works of Toyo Carbon Co., Ltd. This facility has a high pressure vessel with a diameter of 2 m and a height of 4 m. The CIP facility is designed so powder of metal and ceramic put in a rubber mold is isotropically compressed under isostatic pressure at normal temperatures. CIP facilities which have been introduced and installed up to now are used for carrying out R&D and production work. Most of the CIP facilities are small. Even in the case of production work, the high pressure vessel has a diameter of 1.5 m and a height of 3 m. This was the largest size in the world until the above-mentioned facility appeared.

The world's largest CIP facility employs a direct pressurizing system. It is automatically operated by the computer control. The packing work, cleaning work, putting work into buckets, putting work into the CIP, extracting work from the CIP, and storage cycle, are also automated. The high pressure vessel has a switching structure consisting of a number of cylinders, and has a special guide with a view to ensuring the opening and closing of the upper and lower caps. Also, a cylinder switching device is installed on the bottom of the high pressure vessel for the purpose of raising the stability, lengthening the lifespan of seals, and relieving the burden of cleaning and maintenance work such as replacement of packing.

Use of Infrared Optical Fiber Based on Halide Glass in Power Transmission, Etc.

Asahi Glass Co., Ltd., has developed an infrared optical fiber based on halide glass, and has started shipping its samples. Transmission characteristics of this fiber have rapidly been raised. Silica glass optical fiber, multicomponent glass optical fiber, and plastic optical fibers such as PMMA (polymethyl methacrylate), etc., have been developed. These optical fibers are used for short and long distance communications, LAN (local area network), etc. It was impossible to use the optical fibers at long wavelength regions, because they have a minimum theoretical transmission loss at wavelength regions of around 1μ.

On the other hand, it is expected that the infrared optical fiber can be used for spectral analysis, measurement of radiation temperatures, power transmission of CO_2 lasers (wavelength: 10.6 μm) using long wavelength transmission characteristics in long distance communications such as trans-Pacific nonrelay communications, etc., because the infrared optical fiber has a minimum theoretical transmission loss at wavelength regions of around 3.5 μ, and because the theoretical transmission loss is low, being one-tenth to one-ten-thousandth that of silica glass optical fiber.

There are four kinds of infrared optical fibers. That is, they are based on heavy metal oxide glass, halide glass, chalcogenide glass, and halide crystal, respectively. New products are infrared optical fiber based on heavy metal oxide glass and that based on halide glass. Transmission characteristics of the latter fiber have rapidly been raised. The company aims at putting these fibers to practical use as power transmission lines of CO_2 lasers with a wavelength of 10.6 μm by using a laser scalpel, etc. The company also expects that the use of the fibers will be expanded to an industrial power transmission field by using large output CO_2 lasers in the future.

Success of Mass-Production of Rutile Single Crystal by Using FZ

Chichibu Cement Co., Ltd., and National Institute for Research in Inorganic Materials of the Science and Technology Agency have jointly established a technology for mass-producing rutile single crystal with high quality and good refractive index fluctuation by using the FZ (floating zone method). Rutile is a kind of crystal form of titanium dioxide (TiO_2). It is used for optical communication, polarizing prisms of LAN, etc., because it has a double refractive index which means that a refractive index of light greatly depends on crystal orientation. Also, it has been manufactured up to now by using the (Verneuil) method (flame fusion method), because it is an insulator with a high melting point of 1,820°C, and reacts on various pot materials.

However, there are many bubbles and distortion in crystal, and it is difficult to manufacture optical devices with a high reactivity, because the use of this method will cause the uneven and unstable temperatures during crystal growth and their distribution. Also, the supply of rutile is unstable, because the use of the method frequently relies on the user's intuition. The new technology has been developed by using the FZ based on focusing and heating.

High-quality crystal can be obtained by controlling the atmosphere during crystal growth, and optimizing the growth rate. It is said that the fluctuation of a refractive index in crystal will be improved by twice at least and the uniformity of products will be enhanced.

Metals

Compact and Powerful Superconductive Magnet Is Used in Mass Spectrometric and NMR Analyses

Sumitomo Electric Industries, Ltd., has developed a superconductive magnet consisting of niobium 3· and tin, and has commercialized it. It is compact, measuring 16 cm in diameter and 34 cm in height, and generates a high magnetic field of 10 T (teslas). When this superconductive magnet is cooled up to about an absolute zero point by using liquid helium, the electric resistance will be nil. The superconductive magnet is a unit which can generate a high magnetic field at low electric power. When conventional superconductive magnets are cooled, a large amount of liquid helium will be required, because they are large. Also, they have the following problems. 1) Hysteresis (the magnetic field intensity at excitation and that at demagnetization are different from each other even at the same electric current value) is generated in the magnetic field. 2) A superconductive state is broken in the magnetic field.

The company has succeeded in miniaturizing a superconductive magnet by adopting a superconductive wire consisting of niobium 3· and tin and by developing an extremely thin multicore filament structure. This superconductive wire with a world-ranking critical current density is based on a solid-liquid reaction method jointly developed by the company and Agency of Industrial Science and Technology of MITI. This extremely thin multicore filament structure is formed by burying a large number of thin tin wires containing an extremely small amount of copper in the base metal of niobium. The volume of the new superconductive magnet is 60 percent that of conventional ones. The use of the new superconductive magnet will sharply reduce the amount of liquid helium consumed, will shorten the cooling time, and will bring about the bipolar continuous operation of a magnetic field of minus 10 to plus 10 T. It is expected that the new superconductive magnet will be used for mass spectrometric and NMR (nuclear magnetic resonance) analyses, etc. The price is about ¥5 million.

NKK Branches Out Into New Field of Vanadium-Aluminum Alloy

NKK (Nippon Kokan K.K.) will branch out into a field of vanadium-aluminum alloy which is an additive-regulator for titanium-6 aluminum-4 vanadium alloy. The vanadium-aluminum alloy is increasingly used in aircraft parts. The amount of vanadium-aluminum alloy annually demanded in Japan is about 180 tons, and it is considered that more than 50 percent of the about 180 tons are imported from foreign countries. Also, the demand for the alloy is large in the West which has a flourishing aviation industry. Particularly, it is considered that the amount of such alloy demanded in the United States is more than 10 times that demanded in Japan. Therefore, the company has decided to

market not only in Japan, but also in the United States through ILMC which is a joint venture operated in the United States by the company and Martin Marietta Corp. There are two kinds of vanadium-aluminum alloys being manufactured by the company. One consists of 50 percent vanadium and 50 percent aluminum, and the other consists of 65 percent vanadium and 35 percent aluminum.

Luminous Analyzing Unit Based on Glow Discharge System, Which Can Be Used for Analyzing Components of Metal Plating Layers in Depth Direction With Accuracy of Resolving Power of 0.05 μm

Shimadzu Seisakusho, Ltd., has developed a luminous analyzing unit based on glow discharge system by the brand name of "Glow Discharge Lamp Analyzing Unit: GDLS-Type 1015." This unit can be used for analyzing components of solid metal in the depth direction with accuracy of resolving power of less than 0.05 μm. When components of metal plating layers are analyzed, an X-ray analyzing method, a secondary ion analyzing method, and a mass spectrometric analyzing method (SIMS: standards information management system) have been used up to now. But, it is impossible to analyze the components of metal plating multilayers by using the X-ray analyzing method. In addition, the use of the secondary ion analyzing method and the mass spectrometric analyzing method need 10-odd hours. The new unit emits light as a light source in vacuum by assuming a sample surface as a cathode of glow discharge. It measures the depth direction with accuracy of resolving power of less than 0.05 μm by using an ion spatter, and displays the relation between metal plating content and depth on a graph. Also, it can be used for analyzing components of metal plating multilayers with high accuracy and at high speed (within 2 minutes). In addition, it possesses the following features: 1) Components of solid metallic materials can be analyzed with high accuracy regardless of the metal plating content. 2) There is little influence of coexisting elements on the analyzing work. 3) Elements which are liable to become inclusions can be analyzed with higher accuracy. 4) Various composite steel plates for metal plating can be analyzed quantitatively.

The concave curvature radius of the diffraction grating is 1,000 mm, the maximum number of elements is 48, and the analyzing scope is ppm (parts per million) to 100 percent. The price of the vacuum type of 20 ch is ¥60.8 million, and that of the normal pressure type of 20 ch is ¥57.8 million.

Nippon Steel Corp. Branches Out Into a Field of Magnetic Recording Materials by Using By-Product Iron Oxide

Nippon Steel Corp. is planning to manufacture a high-density magnetic memory medium for magnetic printing work and for 8-mm tapes for VTR's (video tape recorder) by using iron oxide which is a by-product generated at the iron manufacturing process, and is planning to put it on the market. The company will start shipping its samples at the beginning of the new year. At present, the annual market scale of magnetic recording materials is about ¥50 billion. It is expected that the scale will be increased to ¥150 billion 10 years hence. That is, the industry of magnetic recording materials is one of the growth industries. The company will produce a semihard magnetic recording

material in which the crystal structure of gamma iron oxide is changed. It is an intermediate material between hard ferrite which is a permanent magnet and soft ferrite magnetized by giving a magnetic field. The company intends to develop a material which can be used for high-density recording work, by exerting its own ingenuities, i.e., by carrying out chemical treatments (change of crystal structure of iron oxide, etc.). In addition, the company will produce pure iron powder by reducing iron oxide, and will put it on the market as a carrier which magnetically transfers magnetic printing toners. The iron oxide which is a raw material for magnetic recording materials is generated as a by-product, when steel plates applied to a cold rolling process are pickled. Of the 80,000 to 90,000 tons of iron oxide distributed annually in Japan, about 40,000 tons are supplied by the company.

Large-Scale Science and Technology Computer and Array Processor for OEM

The branch office of Floating Point Systems, Co., Ltd., located in Japan has started putting two products on the market. One is a new type of 64-bit science and technology computer, "FPS-364" (brandname), and the other is an array processor, "MP32" (brandname) for OEM (original equipment manufacturing).

The FPS-364 is a further developed version of the FPS-164. It has a calculation accuracy of a decimal 15-digit and a processing speed of 11 MFLOPS. Also, it is designed so it can cope with larger scale applications. The maximum memory capacity is 9M words (72M bytes), and the maximum hard disk unit capacity is 5G bytes. In addition, the weight and noise of the FPS-364 are reduced by 60 percent and 50 percent of those of the FPS-164, respectively. Therefore, these improvements enable users to operate the FPS-364 under wide environmental conditions. The price of the FPS-364 with a basic constitution is more than about ¥65 million.

On the other hand, the MP32 is an array processor designed for system integrators and OEM sales in the signal and image processing fields. It can be used for carrying out the calculation of 2D complex FFT (fast Fourier transform) of 1K x 1K within 2 seconds, and has a data transferring capacity of 6M bytes per second.

Electrothermal Transfer Color Video Printer

Seiko Epson Corp. has developed a color video printer (brandname), and has begun marketing it. The color video printer is used for transferring color video images to papers at high speed. At present, the production of VTR has reached 25 million units (actual shipping result in 1984), and the advent of a full-scale color video printer has been expected. The electrothermal transfer printing system developed independently by the company is adopted in the new color video printer. This printer can be used for clearly printing postal cards, etc., at a high speed of 25 seconds per paper. Also, it possesses the following features: 1) The printing energy is one-third that of the melting type heat transfer printing system. 2) The installation of the new printer is only the connection to a VTR equipped with a static mode, using a video cable. 3) High-quality pictures can be obtained even if a head of 100 DPI is used, because a dot area modulation is carried out as a gradation

modulation in the same way as that of printed matters. 4) Adaptable input: NTSC (national television systems committee) composite signal (still picture signal). 5) Expression gradation modulation: Six bits at each color. 6) Printing size: 91 x 73 mm. 7) the number of picture elements: 360 x 216.

Plastics

Mitsubishi Gas Chemical Co., Inc. and E.T. du Pont de Nemours and Co. Establish a Joint Venture, "MGC Du Pont Co."

Mitsubishi Gas Chemical Co., Inc. and E.I. du Pont de Nemours and Co. have jointly established a new company, "MGC Du Pont Co." which will manufacture and market PMDA (pyromellitic anhydride). The raw material of the PMDA is PMA (pyromellitic acid) which will be manufactured by Mitsubishi Gas Chemical Co., Inc. The new company has commenced business. The PMDA is a main raw material for heat resistant polymer and heat resistant plasticizer. Also, it is an aromatic polyvalent carboxylic acid anhydride ($C_{10}H_2O_6$). In addition, it is a main raw material used for manufacturing high-heat resistance and high-function polyimide products such as film, resin parts, coating agent, etc., possessed by Du Pont. The PMA for the new company will be manufactured by using a trimellitic anhydride plant at Mizushima Works of Mitsubishi Gas Chemical Co., Inc. A PMDA manufacturing facility is scheduled to be constructed on a site adjacent to the plant. This facility will start commercially producing PMDA in August 1986. The head office of the new company is in Tokyo. The capital is ¥50 million, which is authorized by both companies. The investment rate for both companies is 50 percent. Also, Masaya Suzuki, director of Mitsubishi Gas Chemical Co., Inc., and Hideo Maki, director of Du Pont Japan will be inaugurated as president and vice president, respectively.

High-Performance Liquid Crystal Polymer Fiber Which Surpasses Aramid Fiber

Sumitomo Chemical Co., Ltd., has developed and begun commercializing a high-performance fiber, "Ekonol Fiber" (brandname) in collaboration with Japan Exlan Co., Ltd. This high-performance fiber is excellent in strength, elastic modulus, heat resistance, etc., as compared with aramid fiber which is said to be the strongest organic fiber in the world. Sumitomo Chemical Co., Ltd., has already developed a high-heat (380 to 400°C) resistance engineering resin, "Ekonol" which is an aromatic polyester liquid crystal polymer, and has put it on the market. That is, the company has succeeded in obtaining high-strength and high-elasticity by spinning the polymer, forming the rigid molecular arrangement, and using the characteristic in which the new product brings about an anisotropic molecular aggregating condition under a melting condition possessed by the liquid crystal.

As shown below, the Ekonol Fiber is superior to the aramid fiber. The tensile strength is 30.8 grams per d, while that of the aramid fiber is 23 grams per d. The tensile elastic modulus is 1,080 grams per d, while that of the aramid fiber is 880 grams per d. The breaking extension is 2.9 grams per d, while that of the aramid fiber is 2.7 grams per d. The knot strength is 6.5 grams per d, while that of the aramid fiber is 4.3 grams per d. In addition, this

new product possesses the following features: 1) The density is about half that of glass fiber, and is less than one-fifth that of steel fiber. 2) The new product is lighter than aramid fiber. 3) The relation between stress and strain during tension tests is linear. 4) The new product is deformed and broken within the elastic limit. 5) the new product has no change of physical properties caused by moisture absorption because the water absorption rate is zero percent. The price per kg is ¥8,000 to 20,000. It is expected that the new product will be used as composite material, optical fiber reinforcing material, cable, etc.

Methacrylic Resin Material Which Can Be Readily Press-Punched

Mitsubishi Rayon Co., Ltd., has developed and marketed a methacrylic resin material, "Acry-Alloy V" (brandname) which can be readily press-stamped, even if the plate thickness of this material is 2 mm. Methacrylic resin is variously used in audio sets, automobiles, FA (factory automation), etc., but the industrial world has required a material with a general-purpose grade, which can be readily press-punched as a material for name plates. The Acry-Alloy V is a resin in which VC (vinyl chloride) is compounded on the basis of methacrylic resin by using a newly developed technology. It possesses the following features: 1) Although it has transparency and weathering resistance close to those of methacrylic resin, it has toughness enough to be press-punched. 2) It is excellent in printing characteristics, heat resistance (thermal deformation temperature: about 73°C), and flame retardance confirming to the UL (Underwriter's Laboratory) standard in the United States. 3) It is a material hard to scratch, because its surface hardness is high. 4) It can be cut with a diamond, because there is little viscosity when it is machine-worked. The size is 1,650 x 700 mm. The plate thickness of standard goods is 0.5 mm. The price per plate thickness of 1 mm is ¥2,290, and that per plate thickness of 0.5 mm is ¥1,480.

Aromatic Polyester-Liquid Crystal Polymer Is Used for High-Performance Engineering Plastics, Etc.

Mitsubishi Chemical Industries, Ltd., has developed an aromatic polyester-liquid crystal polymer, and will start cultivating a market for wide fields such as high-performance engineering plastics, etc. The liquid crystal polymer melts to a liquid crystal condition. It is a high-strength material with self-reinforcibility, because rigid molecular chains cause a reinforcing action similar to that of glass fiber at a molecular order. Up to now, Du Pont in the United States has developed a lyotropic liquid crystal and solution molding type fiber, "Kevlar" (brandname), and Cartco Co., Ltd., in the United States has developed a thermotropic liquid crystal and melting molding type fiber, "Zaydar" (brandname).

The product newly developed by Mitsubishi Chemical Industries, Ltd., is an aromatic polyester-melting molding type polymer. This new product has high-strength and high-moldability equivalent to that of thermoplastic resin. In addition, its heat resistance temperature can be enhanced up to 160 to 170°C, because it has aromaticity. Mitsubishi Chemical Industries, Ltd., will construct a pilot plant with a capacity of monthly production of several

hundred kg in Yokkaichi Works, and will start shipping samples within the year. First this new polymer has been developed as an optical fiber covering product in collaboration with NTT (Nippon Telegraph and Telephone Corp.). In the future, it is expected that the new polymer will be required for fields such as metal, film, fiber, substitute for ceramics, electric, and electronic parts, etc.

Conic's New Plant Completed as Base for Producing Engineering Plastic Molds

Conic Co., Ltd., a manufacturer specialized in the production of precise molds such as punch press molds, etc., has completed a new plant at the industrial complex of Katsuoh Chukaku in Okayama Prefecture. The company has gone into operations on a full scale. The new plant is a ferroconcrete and two-story building with a building area of 3,220 square m. It consists of an engineering plastic precise mold factory building, a press precise mold factory building, and an office building. It is a modern plant equipped with new various facilities such as clean rooms, air-conditioned rooms, design rooms, etc. The clean rooms and air-conditioned rooms are indispensable for manufacturing precise molds and conducing tests on these precise molds. The design rooms employ the CAD/CAM system. In the future, the company is planning to further expand factory facilities. In addition, it will further complete large factories and machine facilities necessary for these large facilities by 1987.

Methacrylic Aramid Resin Is Commercialized and Used for Antifriction Bearing and Printed Board

Teijin, Ltd., has developed a methacrylic aramid resin molding, "Conex CMR" (brandname) in collaboration with Oiles Industry Co., Ltd., and has started putting it on the market. Teijin,Ltd., has already commercialized a methacrylic aramid fiber, "Conex," and has succeeded in developing the above new product by using a molding technology developed by Oiles Industry Co., Ltd., and by using methacrylic aramid powder before spun, as a raw material. Methacrylic aramid is made of a composition of meta-phenylene diamine and chloride isophthalate. The new product possesses the following features: 1) The melting point is high, being 430°C which surpasses 327°C of fluorocarbon resin. 2) It can be used continuously at temperature regions up to 260°C. 3) The coefficient of thermal expansion is lower than that of polyimide. 4) The mechanical strength is high. 5) It is flexible. 6) The performance can be maintained even at a temperature of 200°C. 7) Cutting work can be readily carried out. 8) The resistance to wear is high. 9) It is excellent in sliding and electrical-insulating properties. The price for a round bar is more than ¥10,000, and that for a disk is less than ¥50,000. The new product is used for roller, antifriction bearing, printed board, shield material, etc.

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STATUS OF PLASTIC OPTICAL FIBER MATERIALS DEVELOPMENT

Tokyo OPTRONICS in Japanese Feb 86 pp 67-71

[Article by Yasuharu Ohtsuka, Applied Chemistry Division, Department of Science and Engineering, Keio Gijuku University: "The Present Condition of Plastic Optical Fiber Materials--the Attention-Atracting Macromolecular Optical Functional Material"]

[Text] 1. Preface

Optical communications came into the limelight when the quartz-based optical fiber of 20 dB/km in transmission loss was developed by Corning Corp. of the United States in 1970 and the semiconductor laser emitting light continuously at room temperature was developed by Bell Research Institute, United States. Since then, vigorous efforts have been made to reduce the transmission loss of optical fiber and to increase the performance, as well as the service life of the semiconductor laser as a light source that developed into the large-capacity fiber communications systems of today.

In Japan, the ultra-low-transmission loss optical fiber of 0.2 dB/km at 1.55μm was produced while semiconductor laser with longevity of several tens of thousands of hours was developed, completing the trans-Japan optical cable from Hokkaido to Kyushu in 1985, resulting in the practicalization of the large-capacity optical communications system of 400 megabits/second.

The transmitting capacity of optical communications is the microwave which is comparatively superior to the milliwave. However, the basis of optical communications systems is to transmit information by turning the light on and off, which is no different from the elementary method and is at an extremely low level from a viewpoint of effectiveness in the use of light frequency. Research is being carried out actively to utilize the high-frequency characteristic of light with coherent optical communications for the future to further increase capacity size and enhance long-distance extension. This research has many technical issues, and although practicalization is not as easy as it appears, its realization is expected.

In the meanwhile, plastic optical fiber is larger in diameter, higher in numerical aperture, more easily processed, less expensive than quartz-based optical fiber. However, the transmission loss is essentially greater and not sufficient in heat resistance. It must be dealt differently from the quartz-based optical fiber as follows:

In the past, plastic optical fiber had limited use such as in light monitoring, light guides and displays in automobiles. However, with the recent advance in technology in reducing the transmission loss of plastic optical fiber, polymethyl methacrylate-based optical fiber (PMMA) exceeding 100 dB/km (567 nm) is now on the market while in the test laboratories, plastic optical fiber of 20 dB/km (680 nm) has been developed. In addition to this, the improvement of light-emitting and light-receiving devices is progressing, which operate within the low-loss area (visible light) of plastic optical fiber. Furthermore, the use of optical communications systems has become active in short-distance transmission such as in OA, FA, LAN (local area network). Plastic optical fiber is widely recognized to be of great service in these fields.

Together with a focus on plastic optical fiber, the present status will be described hereforth.

2. Structure and Function of Plastic Optical Fiber

Optical fiber is classified into two major types from its function--the index type (SI type) and the graded index type (GI type).

The SI type, as shown in Figure 1, is composed of a core with a refractive index of n_1 and a sheath with a refractive index of n_2. The n_1 is larger than n_2. Quartz-based optical fiber is about 1 percent in contrasted refractive index differential ($\Delta \cong (n_1-n_2)/n_1$). The core is 50 μm and the fiber is 125 μm in diameter, respectively. If made of plastic, it is $n_1-n_2 \cong 0.1$. The core being 0.1 to several mm in diameter, the sheath being thin with a thickness from several μm to 20 μm.

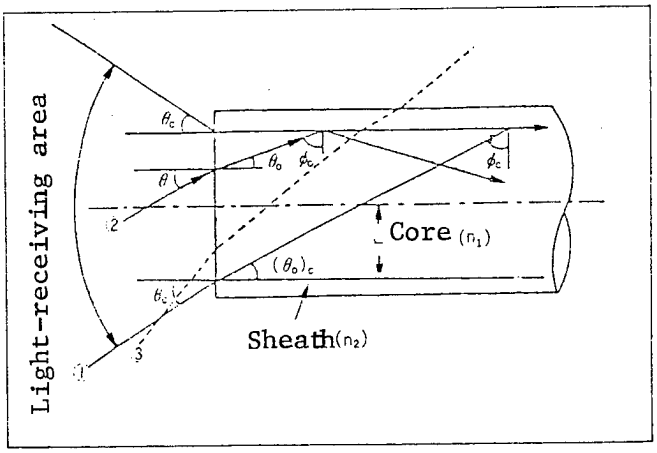


Figure 1. SI Type Optical Fiber Structure and the Optical Path

Light is propagated here, repeating total reflections between surfaces of the core and sheath. Equation (1) below represents critical value of incident angle (θ) in total reflecting light at an end surface.

$$\sin\theta_c = \sqrt{n_1^2 - n_2^2} \qquad (1)$$

$2\theta_c$ is the light-receiving angle and equation (1) is called the numerical aperture (NA). Only the light that goes into the fiber satisfying requirements indicating an inclination toward the fiber central axis is propagated as a stable wave. Several such stable waves are propagated simultaneously (multimode). As mode waves with greater incident angle θ ($\theta \leq \theta_c$) are slow transmission speed, pulse light distorts with longer propagating distance (mode dispersion) making it unsuitable for long-distance communications. This type of fiber is suitable for short distance optical communications.

The GI type sheath has a refractive ratio distribution as shown in equation (2) below.

$$n(r)=n_0\mathrm{sech}(gr)\cong n_0(1-\frac{1}{2}g^2r^2)\cong n_0(1-\frac{1}{2}Ar^2) \tag{2}$$

Thus, n_0 is a refractive index at the axis center, n(r) is the refractive index at a distance of r from the center, while g and A are constants. The refractive index at the sheath is equal to that at the outer surface of the core. Light meanders along the axis center. Several mode waves are propagated at the same time while their propagating speeds are nearly the same, having the capacity for longer distance communications than the SI type.

The GI type quartz-based fiber is already on the market as an important transmission path, but the plastic-based fiber is still in the research stage and not yet on the market.

It is possible to make only a single mode wave for propagation by rendering the diameter of an SI type core smaller (10 μm) to reduce the difference between n_1 and n_2 to be (Δ = 0.2 percent). Even when the pulse wave is propagated for a long distance, the strain of the pulse wave is extremely small so as to permit ultra-high-speed, long-distance communications. This is in the single mode type optical fiber. It was used in previously mentioned trans-Japan optical cable. Fine fiber as such has not yet been made from plastics.

If light with an intensity of I_0 becomes I after being propagated through a fiber axis to a distance of L, the transmission loss of optical fiber can be formulated as shown in equation (3)

$$I/I_0=\exp(-\varepsilon \cdot l)$$

$$\text{transmission loss}[\mathrm{dB/km}]=-(10/l)\log(I/I_0)=4.343\varepsilon \tag{3}$$

ε is a sum of adding loss through light absorption (α) and light scattering (γ) at the core to the loss occurring at the time of total reflections of light between the surfaces of the core and the sheath--in other words, loss due to structural irregularity (ω).

3. Organic Polymer as Optical Fiber Materials

3.1. Refractive Index and Abbe Number

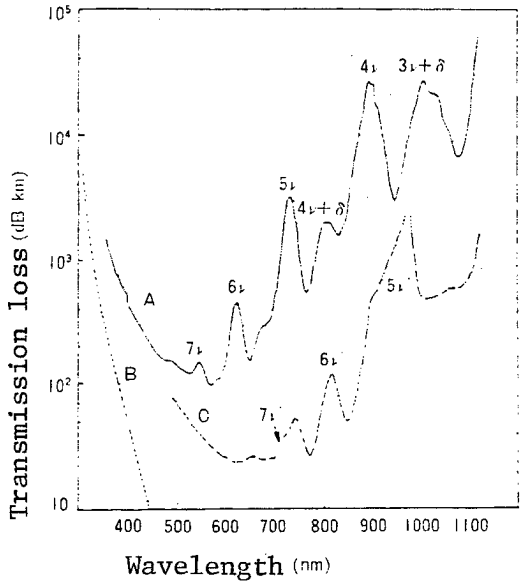
Core polymer is required to have a high refractive index and sheath polymer a low refractive index. In addition, as the light source for optical communications is not a perfect single light and has some wavelength distribution, the refractive index of core polymer depends on the wavelenfth to a great extent (low Abbe number), and the strains of pulse wave were great (material dispersion). Theoretically, a high Abbe number is required. A high refractive index organic polymer is prone to become low in refractive index. Contraty to theory, the effect of dispersed material is much smaller than that of mode dispersion.

3.2. Transmission Loss

a. Absorption Loss (α)

Organic polymer has a large amount of oscillating absorption in an infrared area and a strong absorption caused by a degree of electronic excitation in an ultraviolet area, which contrasts to the visible light area.

The intensity becomes less at the base of ultraviolet absorption as the wavelength becomes stronger. The curve B indicated in Figure 2 (transmission loss of PMMA-based fiber) shows the estimated value of ultraviolet absorption effect. In this case, the effect is very small for the visible area, but some effects are recognized in polystyrene (PSt).



(A) PMMA/fluorine-contained polymer
(B) Estimated value of electronic transition absorption
(C) Deuterated PMMA/fluorine-contained polymer
ν: C-H flexible oscillation
δ: C-H variable angle oscillation
ν': C-D flexible oscillation
$n\nu$, $n\nu'$: Respective n sound times
$n\nu + \delta$: Combined sound respectively

Figure 2. Transmission Loss of PMMA-Based Optical Fiber

The effect of oscillating absorption in the infrared area is important. Absorption of overtone and combination tone of C-H standard oscillation takes place in the visible area. The peak of curve A in Figure 2 is an overtone of a C-H combination of PMMA. The absorption intensity is reduced by about 1 digit as the level becomes higher.

When hydrogen is replaced with heavy hydrogen as the C-D standard oscillation shifts into a long wavelength as does the overtime, a higher level of overtone emerges in the visible area and absorption intensity becomes less.

Such absorption is peculiar to raw materials and external factors such as impurities and additives bring about absorption loss. Therefore, very pure polymer is necessary and, for that purpose, an additive-free polymerization process is necessary for refining monomer (for example, massive polymer).

b. Scattering Loss (γ)

Crystal polymer, graft copolymer, block copolymer, and polymer blend usually show micro-phase separating structure, respectively, and their scattering loss is great. Random copolymer which is wide in composite distribution is also considered to have greater scattering loss due to phase separation. Let us think about the scattering loss of noncrystal homopolymer.

Scattering resulting from the wavering density of solid noncrystal homopolymer is smaller than that of fluid materials. In PMMA, 11 dB/km is observed at a wavelength of 633 μm. Moreover, polymer which is polar-based having a greater anisotropic effect, such as polystyrene (PSt) or polycarbonate (PC), has greater scattering loss due to Hν (horizontally polarized light scattering from vertically polarized light).

Such scattering losses are inherent to polymer. However, actually, there is greater scattering loss due to nonuniformity resulting from a variety of external factors. In the polymerizing conditions by thermal and mechanical hysterisis deformation remains and forms minute holes in the solid polymer that cause scattering. There is no change in the inherent scattering loss due to degree of polymerization. However, in that a low polymerization degree makes it easier to remove deformities, the following was reported. The scattering loss of PMMA and PSt becomes less the more the polymerization degree is lowered and fabricated at a higher temperature. Further, the effect of the nonuniformity in dust and air voids is extreme. However, when low monocular coexisting matter, such as the remaining monomer and plasticizing agents, scatters in a state of monoclue, there is no effect on scattering loss.

In reducing scattering loss, it is important to prevent pollution during the refining and processing period and to remove the remaining deformities as well. The problem of scattering posed to plastic optical fiber is Rayleigh scattering in which the size of scattering objects must be small enough compared to that of the light wavelength with scattering loss at the fourth power of inverse proportion to the light wavelength. The longer the wavelength, the smaller the scattering loss.

c. Loss Through Erratic Structure (α)

When light reflects totally on the surfaces of the core and sheath of plastic optical fiber, some light leaks out in the sheath. It is necessary for the polymer in the sheath to be transparent. Moreover, the unevenness and peeling off from the surfaces of the core and the sheath makes ω greater. It is necessary to adjust affinity and fusion viscosity of materials for the core and the sheath. Copolymer, polymer blend, and additives are added to compound suitable materials for the sheath.

3.3. Dynamic and Thermal Characteristics

The degree of tensile strength and refractive resistance are required. The polymer chain is to be orientated to some extent when stretched. Orientation tends to lower transparency and the dynamic characteristic must be improved without impairing light transparency.

As heat resistance is necessary, polymer with a high temperature (Tg) glass transition is desirable.

The characteristics mentioned above are required in the raw materials for optical fiber. Among these requirements, there are a few that are conflicting. It is difficult to find any polymer satisfying all the requirements.

4. Performance of Plastic Optical Fiber

As explained earlier, only the SI type plastic optical fiber is on the market. The description here will be focused on the SI type fiber and limited to possibilities of the GI type.

When plastic which is or was on the market is classified according to raw materials for the core and sheath, there is 1) PMMA/fluorine-contained polymer; 2) PSt/PMMA; and 3) heavy-hydrogenated PMMA/fluorine-contained polymer. The 2) has currently been discontinued for production and 1) has become the focus.

4.1. Manufacturing Techniques

a. Heat-Stretching Technique

The core and sheath are heat stretched after preforms are made. This is the method for producing the GI type fiber.

b. Coating Technique

After the core fiber has been produced, a solution or melted matter for the sheath is applied.

c. Compound Spinning Technique

The melted core and sheath compound is pushed out through a nozzle for compound spinning to make the compound structure of the core and sheath. This is the most advantageous technique industrially.

4.2. PMMA/Fluorine-Contained Polymer Type

Items indicated in columns 1 through 3 in Table 1 are on the market.

The improvement of PMMA as a core material in purity and the application process for preventing impurities such as dust from being mixed can lower transmission loss to a considerable degree. (Refer to the column "characteristics of manufacturing techniques.") The curve line A in Figure 2 is the loss curve in column 3.

Moreover, the coating of components to make the sheath immediately after spinning following polymerization of MMA on a completely enclosed system at the laboratory scale can further reduce transmission loss as shown in column 4.

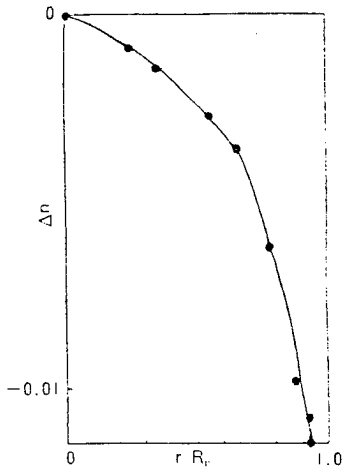


Figure 3. MMA-VPAc Base GI-Type Light
Fiber refractive ratio distribution
Fiber diameter (2Rp) = 1.0 mm

4.3. Heavy Hydrogenized PMMA Fluorine-Contained Polymer Type

Optical fiber with heavy hydrogenized PMMA as material for the core has already been commercialized by Du Pont (Pifax PIR), but did not sufficiently achieve low transmission loss. However, the manufacturing process being the same as in column 4 in Table 1 makes it practical to produce fiber of low transmission loss as curve C shows in Figure 2. $n_1 = 1.485$, $n_2 = 1.395$, numerical aperture = 0.51, transmission loss: 20 dB/km (680 nm), 25 dB/km (780 nm), 50 dB/km (850 nm). It is usable in the near-infrared area. This is one of the important types for enhancing reduction of transmission loss.

Table 1. PMMA-Based Optical Fiber

	#1	#2	#3	#4
Core polymer	PMMA group			PMMA
Sheath polymer	Copolymer of vinylidene tetrafluoroethylene fluoride. Copolymer of methacrylic acid ester in fluorine-contained alcohol.			Methacrylic acid alkyl fluoride-based copolymer
Refractive ratio at core	1.495	1.495	1.492	1.490
Refractive ratio at sheath	1.402	1.402	1.417	1.395
Numerical aperture	0.50	0.50	0.47 ± 0.03	0.52
Light-receiving angle 2 θ_c (degree)	60	60	56	63
Transmission loss (wavelength) (dB/km (nm))	Approximately 550 (650)	300(650)	95(567) 160(650)	55(568) 128(650)
Characteristics of manufacturing techniques	PMMA through suspension copolymerization used for core material. Compound spinning technique.	PMMA through continuous massive copolymerization used for core material. Compound spinning technique.	Preventing impurities from being mixed through direct connection of spinning process with continuous massive polymerizing process in making core material.	MMA polymerized in a vacuum type completely enclosed system, spun as is, proceeding to coating of sheath material. In research stage.

4.4. GI-Type Optical Fiber

In order to produce GI-type fiber, it is necessary to render refractive ratio distribution to compound macromolecule. For this purpose, there are various methods, such as: 1) diluent swelling method: 2) graft-copolymerization method; 3) chemical reacting-polymer degeneration method; 4) two-stage copolymerization method; 5) optical copolymerization method. Of these methods, the GI-type optical fiber will be described.

After the selection of a combination where M_2 is easier to copolymerize than M_1 from vinyl monomer (M_1), high in refractive ratio, and vinyl monomer (M_2), low in refractive ratio, a mixture of M_1 and M_2 is copolymerized in a cylindrical container and subjected to a blinking light. As copolymerization progresses, low refractive index copolymer is educed at the inner wall of the container, and at its center, high refractive index copolymer is educed, producing refractive ratio distribution.

For M_1-M_2 type, there are the methacrylic acid ester-vinyl benzoat (VB), the MMA-vinyl phenyl acetate (VPAc), etc. It is possible to increase the gradient of refractive index quickly by changing the binary monomer type into a ternary monomer type. For example, there is the MMA-VB-Acrylonitrile type.

When the rod obtained is thermal stretched, it becomes the GI-type optical fiber. Shown in Figure 3 is the refractive ratio distribution of copolymer of MMA-VPAc. The transmission loss is relatively great. However, since GI-type optical fiber can reduce loss ω through erratic structure, it is a matter of time before the advent of materials with lesser transmission loss is realized.

5. Light-Emitting, Light-Receiving Elements

PMMA type optical fiber has a low-loss area in the vicinity of 567 nm and 650 nm. With the (green) light being lower in loss. However, at the present, the output of LED in emitting green light in this area is small. For practicalization it is necessary to enhance greater output.

As for the latter low-loss area (red) light emitting LED, there is the GaAlAs LED. This is a mixed crystal of GaAs and AlAs, where the mixing ratio can control light-emitting wavelength to some extent. λ_0 = 660 nm, output: 1-2 mW high-speed responsiveness of about 30 nsec has already been realized.

For a light-receiving element, an improved diode, the SiPIN photo diode, with sensitivity comparable to 660 nm, is now on the market.

6. Future Issues

The major issue for the future is to enhance reduction in transmission loss of plastic optical fiber and improve heat resistance.

The chemical structure of the material determines light absorption loss (α) which determines the low-loss area. As the inherent value of scattering loss becomes lower, the lesser polymer has optical anisotropy effect of

chemical structure polarity base. However, the scattering loss of fiber actually marketed is influenced by a variety of outside factors which is, surprisingly, far greater than its inherent value. There is room for improvement. The spinning process of the material must be studied. Loss (ω) resulting from erratic structure depends on matching and prefabricating processes of materials for the core and sheath, leaving room for improvement.

A shift of a low-loss area into a long wavelength after reviewing the chemical material structure reduces the low-loss area as scattering loss becomes lower in proportion to λ^{-4}. This example is heavy hydrogenization.

For improvement of heat resistance, PC is under study where the use of polymer high in glass-transition temperature (Tg) is considered. The key is in the addition of transparency with polymer in amorphous state.

The use of isostatic type polymethyl pentane is under study as well. This is polymer without polarity and is said to have an extremely small gap in density between crystals and noncrystals despite its tendency of crystallizing.

Polymer which introduced bulky alicylic base into side chain is of our great interest as an optical fiber material. Polymer which introduced trisicrodecanil base into methacrylic acid ester is high in nd, having relatively high ν_d as against PMMA, with high Tg (175°C) low in water content. Due to the materials having the desired characteristics, there is a need to study this type polymer.

For light-receiving elements, in the wavelength area where transmission loss is at the lowest, the light source of high-output, high-speed respondency is not available. Development is necessary on this point.

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CSO: 4306/3598

NEW MATERIALS

EFFECTS OF KYOCERA PRESIDENTIAL CHANGE DISCUSSED

Tokyo KEIZAIKAI in Japanese 17 Jun 86 pp 42-46

[Text] Since last year, the rumor has become more widespread that Kazuo Inamori, chairman and president of Kyocera Corporation will turn over the position of president to Yoshihisa Anjo, a vice president of Kyocera, and that Inamori will serve exclusively as chairman. It is reported that this is because the problems with artificial bones, and weapon exports have been settled for the time being. Kyocera is experiencing a decrease in revenues and profits for the first time in 8 years, and it seems that the myth of Kyocera's rapid growth has faded. One wonders how "Saint Inamori" will overcome the greatest crisis that Kyocera has faced since its founding.

The Time for Presidential Change Is Near

Will Kazuo Inamori, president of Kyocera Corporation, become chairman? Right after reading this "scoop" in the NIHON KEIZAI SHIMBUN, I called the head office of Kyocera, and asked, "Will he serve as chairman?" The reply was, "That article was speculation. No decision has been made yet." Then I tried fishing for information, saying, "Still, the company has been losing money, hasn't it?" The response was, "Well, that's because semiconductors are not doing well. However, since our company has a low break-even point, we haven't gone into the red." That is just as Mr Inamori said: If it were another company in the same industry, it would be in serious debt. Thus, the myth of Kyocera's increasing revenues and profits has proven wrong. Nonetheless, a recorded profit of 38 billion yen isn't all that bad.

I told Mr Inamori, "it's unusual for one man to serve simultaneously as president and chairman. I think you should be one or the other." Mr Inamori replied, "I certainly appreciate your advice."

It has been a long time since Mr Inamori's friends Jiro Ushio (chairman of Ushio Electric Inc.) and Makoto Iida (chairman of Secom Inc.), both of whom founded their companies, changed from being president of their companies to being chairman.

Mr Inamori said, "I really think it would be better to leave the management of daily affairs to a new president, and oversee the affairs of the group as a

whole." I added, "You would still be contributing to the prestige of the company." Mr Inamori responded, "Thank you for your kind words."

I said to Mr Inamori, "I myself think it would be a good idea for you to become chairman. That would be crucial to the future of 'Daini Denden.'" Mr Inamori said, "Thank you for your thoughtfulness." The old "Inamori the fighter" has been revived.

When I met Hisashi Shinto, president of Nippon Telegraph and Telephone Public Corporation (NTT), I asked for his "evaluation," of Kazuo Inamori, president of Kyocera. He responded that, "He shouldn't be so tough. He should be a little more relaxed." After that, he remarked in regard to the "Inamori Prize": "He's too young to be doing something like that. I think he should wait until he's older." When I asked about the future of Daini Denden, which is under Mr Inamori's leadership, and is a competitor of NTT, Shinto said, "I think everything will be all right."

When I met Mr Inamori in Tokyo, after he had arrived from Kyoto, I told him what Mr Shinto had said. Mr Inamori said that, "I spoke with Mr Shinto about the telephone lines. He told me, 'Telephones and telegraphs in Tokyo are running deficits. Please share your part of the burden.' I told him that there are a lot of stockholders, so we couldn't do it. He scolded me, saying, 'You only say things that sound good.'" Mr Inamori continued, "Nevertheless, Mr Shinto is a great person. As president of NTT, he has nothing but love for his company." Although he was scolded by Mr Shinto, he did not hesitate to acknowledge his good points.

Kyocera Under Attack by the Media

Last year was a rough one for Kyocera and its spiritual leader Mr Inamori. The problem with artificial bones was taken up by the Diet, and the media made an all-out assault on the company regarding the problem of weapon exports. Inamori and Kyocera were attacked bitterly in the press concerning these problems. Although Kyocera showed a profit of 72 billion yen in the period before the last one, the profit in the last period fell to 38 billion yen.

Moreover, there has been a severe drop in semiconductor sales due to the stronger yen. Kyocera now finds itself in a pitch dark tunnel and is groping its way out.

However, Mr Inamori is optimistic, "Still, the demand for semiconductors has increased since around October of last year. The current period is difficult, but we expect to see a recovery of 5 billion yen in profits in the next period." I asked, "What is your present state of mind?" Mr Inamori responded, "As I see it now, I'm glad I was scolded. I don't have any sour grapes. After all, no one should have really expected such high growth to continue. I guess God was testing me."

I wrote a rather stinging report a year ago that predicted, "If Inamori commutes from Kyoto to Tokyo, Daini Denden will fail!" In that article, I maintained that Mr Inamori should turn over management of Kyocera to someone

else, and move to Tokyo with his family to devote his energies to the management of Daini Denden. The tone of the article was rather harsh.

Mr Inamori told me, "I understand what you were saying." Later, Inamori's close friend Jiro Ushio, chairman of Ushio Electric Inc., told me, "Since then, Inamori has been coming to Tokyo to work for three or four days at a time. The medicine was quite effective." Before then, Mr Inamori had been actually commuting between Kyoto and Tokyo, returning to Kyoto on the same day or the next morning.

Kyocera's Failed Entry into the Camera Business

Kyocera's original business was ceramics, in other words, "pottery." The company had almost a monopoly in this field. However, the market for ceramics is a small one less than 1 trillion yen. This was Kyocera's "Achilles Heel."

According to Mr Inamori, "The field of ceramics requires 50 percent study and 50 percent experience. We have a lot of confidence that we can turn out good products. I am an 'artisan.'" Mr Inamori's philosophy is to make good products and thereby make a contribution to society.

Semiconductors, one of the pillars of Kyocera, are being over-produced on a worldwide basis, which is depressing prices and causing a slump. Kyocera has fought desperately in this field.

Then there is the camera company Yashica, which Kyocera has acquired. I asked how the camera business is going. Mr Inamori replied, "In that area, we're putting up a good fight." Yashica was just on the brink of insolvency, when Mr Inamori saved it from certain failure. Mr Inamori made a difficult decision.

The employees of Yashica were happy to become employees of Kyocera. Kyocera, a so-called secondary maker of ceramics and semiconductors, then became involved in the manufacture of primary products in the field of optics. Thus, "Kyocera-Yashica" entered the camera business.

However, these cameras had no special features. They were neither high quality cameras nor were they cheap and simple push-button cameras either. Rather, they were somewhere in between. A journalist friend of mine remarked, "I'd be embarrassed if anyone saw me walking around carrying a Yashica camera." Nikon and Canon cameras are of the highest quality. Minolta also has special features. Yashica cameras just aren't in the same league.

It seems to be a fact that when makers of secondary products try to make primary products, they wind up failing. Chinon and Sankyo Seiki entered the 8mm camera business, but failed. Mitsumi Electric also tried to make it in primary product manufacturing, but also ended up in failure. Of course, the procedure for distribution is fundamentally different for primary and secondary products.

I think that Kyocera's entry into the camera business is a failure. They have "chased the enemy too far." They have already spent a lot of time on this but

have gotten nowhere. It's time for them to get out of it. The way to recognize a good manager is by his skill in executing a strategy for withdrawal.

One method would be to convert the Okatani Factory in the Shinshu area into a semiconductor plant. When I suggested this, Mr Inamori said, "Give me a little more time. I'd like to make a final decision on this after I have looked at every angle." Saying that, he admits that Kyocera's technical group is rather deficient, and feels that the introduction of optical technology would be a plus for the company in the future age of "composites." In this sense, the purchase of Yashica is a minus in the short term, but will be a plus in the long run.

The Birth of "Inamoriism"

Mr Inamori told me, "Canon's President Ryutaro Karai is taking me out to dinner today." Important parts of Canon's products are made by Kyocera. He said, "We're satisfied to be just a 'beauty spot.' If Canon helps us to expand our technology, we couldn't be happier." That is one of Kyocera's strong points.

Kyocera was originally called Kyoto Ceramics, and was a local industry in Kyoto. Thanks to the superb leadership of Kazuo Inamori (who is almost like a religious leader), the company grew from a tiny ceramics maker to a large company in tune with the times.

Mr Inamori was born in Kagoshima. His youth was marked with illness, and, bluntly speaking, he was not a gifted student. Thus, he was unable to enter Tokyo University, or one of the top private universities such as Waseda or Keio, and instead had to go to a third-rate university, Kagoshima University in Kyushu. He was not brilliant.

Once, when I spoke with Mr Inamori at a meeting of the Keizaikai club, I said, "Mr Inamori, it's quite a feat that you graduated from a third-rate university and made it this far!" To which he shot back, "And what about you?"

The lack of "proper" university credentials was actually a fortunate thing for Mr Inamori, since he was not able simply to rest on his laurels. Since he graduated from a third-rate university, he was not able to join a first-rate company, so he was employed at a small ceramics company in Kyoto called Matsukaze Kogyo, where he worked in obscurity. The company finally went bankrupt, and Inamori's story of unemployment and independence is now famous.

Thanks to the help of a lot of people Kyocera achieved miraculous growth. I wanted to know, "What is the secret to your success?" Mr Inamori replied, "That's due to none other than divine protection. You see, a lot of things happened that could not have been conceived of by conventional human wisdom. They were not just accidents." I was impressed with Mr Inamori's deep faith in divine protection. As a young man, Mr Inamori's first encounter with religion was the "Seicho no Ie." Inamori read the book "Life and Reality," by Masaharu Taniguchi, founder of "Seicho no Ie," who wrote, "Human beings are children of God. The reality of human existence is that they are children of

God, with no sickness and no confusion." The young Inamori, struggling with his illness, was not just moved, but eagerly read the book while sobbing. He read the book over and over, until it was carved into his soul. Taniguchi's philosophy is not one that can be stated in just a few words.

When Mr Inamori first came to Kyoto, he had the opportunity to meet a famous Buddhist priest. When he had difficulties making decisions, the words of the priest would open the eyes of his soul. But whether it is God or Buddha that gives humans a great mission, it is never easy to carry it out. One must fall into the depths at least once, and sometimes two or three times, and only those who crawl out are then led as children of God or children of Buddha. Even the venerable Konosuke Matsushita himself had to go through this before he built his great company.

A Turning Point for Kyocera

It is my opinion that the Kyocera Corporation and its manager Kazuo Inamori have reached the point of departure from an enterprise of middle standing to become a big company. Not even Wacoal or Omron Tateishi Electronics Co. have left the ranks of medium-sized enterprises. It is unfortunate that the Kyoto business world is populated with stingy and complacent managers. I think that Mr Inamori is the only one among them with the potential to become "first-class."

Mr Inamori's strength is that he has Ryuzo Seshima as a mentor. Mr Seshima treats Mr Inamori as if he were his own son. He says of Inamori, "He has a pure and simple heart. If he asks me to do something, I can't refuse." Seshima thus became chairman of the Kyoto Prize Foundation. It is impossible to measure the effect of the appointment of Mr Seshima as chairman.

Mr Inamori has also had the help of his close friends Jiro Ushio, chairman of Ushio Electric Inc. and Makoto Iida, chairman of Secom Inc. They are both stockholders and managers of Daini Denden. Mr Ushio and Mr Iida are topnotch men in their generation.

I asked Inamori what he thinks of Mr Ushio. He replied, "He's just like an older brother to me. I feel confident in following his example. There is no friction between the two of us."

When asked about Mr Iida, Mr Inamori said, "I consider him a great man, because he gave our company a lot of security." Mr Inamori is a good judge of character.

Mr Inamori has a way of attracting people who are on a high spiritual level. "I myself do not have so much spiritual power, but I have learned how to distinguish people who are truly spiritual from those who are not. I was once told by a very spiritual person that I am on a high spiritual plane." I did not have the impression that Mr Inamori was flattering himself.

Mr Inamori is no ordinary man. He has a positive outlook on life, and is not a troublesome personality, like other people in the "Kyoto business circle." That's because Mr Inamori has gone beyond the limits of Kyoto, and has

nurtured Kyocera from a small local industry to an internationally known corporation.

Up to this point, the employees of Kyocera have been inspired by the strong leadership of Mr Inamori. From now on, they will be led by the power of the organization, with the help of Inamori's parental guidance.

After the interview, Mr Inamori politely accompanied me to my car. As he smiled and shook my hand, I felt confident that Kyocera's future is a bright one.

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PROBLEMS, PROSPECTS OF FUSION REACTORS EXAMINED

Tokyo PUROMETEUSU in Japanese Nov 85 pp 50-52

[Article by Shigeru Mori, a director of the Japan Atomic Energy Research Institute]

[Text] It is well known that nuclear fusion is the source of energy in the sun and fixed stars. Nuclear fusion reactions with the highest probability of occurrence are the fusion of heavy hydrogen and tritium to produce helium, which produces neutrons, and the fusion of heavy hydrogen with others to form helium, which produces neutrons and protons. The idea is to harness the energies of the neutrons and protons for power generation in a reactor.

For a fusion reaction to take place, it is necessary for the particles to collide with each other at high speed. The speed is usually expressed as the equivalent of the particle temperature. For a fusion reaction to become a source of energy, the particles must keep colliding at a high frequency. To satisfy this condition, particles numbering more than a certain count need to be confined in a specialized space for a certain time. When matter is heated to a high temperature, it first becomes a gas and then goes on to become plasma, a state in which electrons and atomic nuclei are separated. A fusion reactor requires a reactor core plasma with a temperature of 200 million degrees and a particle density of 100 trillion particles per cubic centimeter (equivalent to about one-hundred thousandth of a particle density of gas at normal temperature).

Fusion Reactor as the Energy Source of the Future

Fusion reactors have sufficient deuterium fuel reserves to keep them running for more than 100,000 years, and they produce only harmless helium. The reactor gains a relatively small level of radioactivity from the induced emissions, and even with the current technology, radioactive materials inside the reactor can be handled relatively safely. Such features of the reactor make it an attractive candidate as the energy source for the future. But, the use of reactor core plasma has no precedent on earth, and consequently it will require much human wisdom and cost before the use of the reactor core plasma can be realized and harnessed as an energy source.

An example of a power reactor under consideration at present is shown in Figure 1. As shown in Table 1, it is capable of producing 1 million kw in

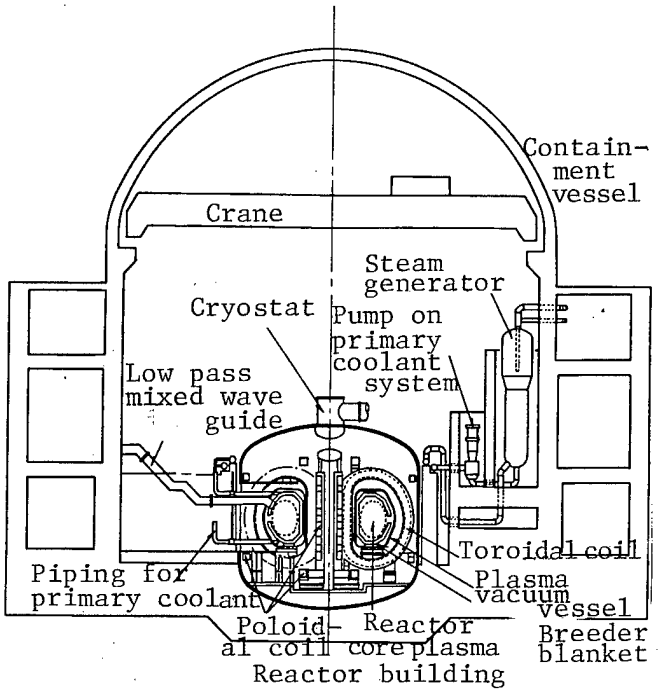


Figure 1. Layout of Practical-Use Power Reactor Inside Building

Table 1. Major Design Specifications for Practical Power Reactor

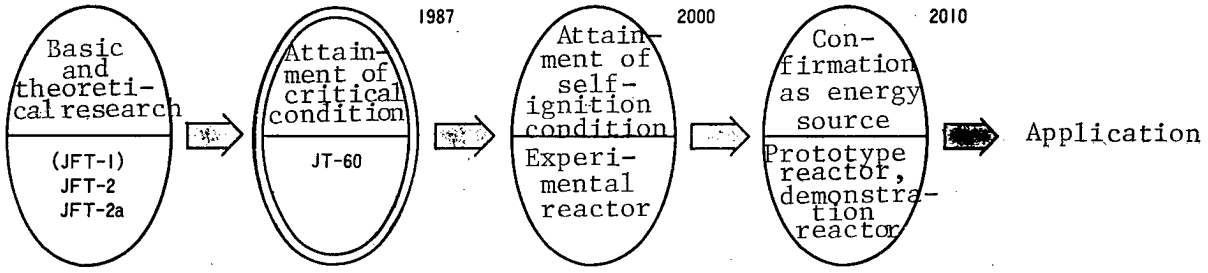
Nuclear fusion output (MW)	3,200
Thermal output (MW)	3,700
Net electrical output (MW)	1,000
Neutron wall load (MW/m^2)	3.3
Main radius (m)	6.9
Plasma radius (m)	2
Elliptic degree of plasma	1.6
Average plasma temperature (keV) (1 eV = 11,600°K)	20
Average plasma density (m^{-3})	1.1×10^{20} (100 trillion/cm^3)
Total beta value (percent) (confinement efficiency index)	7
Plasma current (MA)	16.0
Toroidal magnetic field on plasma axis/maximum magnetic field (T)	5.2/12.2
Toroidal coil	
Number	14
Magnetomotive force (MAT)	180
Accumulated energy (GJ)	55
Wire (superconductive)	$NbTi/Nb_3Sn$
Poloidal coil (hybrid system)	
Number	8
Accumulated energy (GJ)	15
Wire (superconductive)	NbTi
Primary coolant	light water
Pressure (MPa)	16
Inlet/outlet temperature (centigrade)	290/330

electric output. The power reactor is a result of more than 20 years' research on plasma physics. An experiment was begun in April of this year using the JT-60 at the Japan Atomic Energy Research Institute to achieve the break even plasma condition, and the objective is expected to be reached soon. The JT-60 may be said to represent a developmental stage in which the feasibility of a nuclear fusion reactor is scientifically demonstrated.

The next stage is the R&D of an experimental reactor, where the emphasis is placed on demonstrating the feasibility of the engineering technology. With the day for the attainment of the objective of the JT-60 approaching, concrete plans are beginning to materialize for the study of an experimental reactor. The next step is expected to be to proceed with R&D of a prototype reactor and a demonstration reactor, and the final stage will be the development of a power reactor for practical use, where the emphasis is placed on demonstration of the economics of a fusion reactor. These developmental stages are expected to proceed along the time schedules shown in Figure 2, and practical use of power reactors is expected to be realized beginning about the year 2020 to 2050. The three factors of science, technology, and cost-effectiveness are, of course, closely related, so an examination of the image of a practical reactor and its economics at this stage would be especially useful in forecasting the direction of future R&D.

The reason for the length of time necessary for the development of fusion reactors is this: several critical technologies are needed to arrive at the unprecedented reactor core plasma state. The following is an example of such technologies. A high-temperature reactor core plasma needs to be confined within the cage of a doughnut-shaped line of magnetic force generated by the toroidal coil (circular shape) and "poloidal" coil (azimuth direction) shown in Figure 1, and the required strength of the magnetic force is 5.2 tesla (52,000 gausses). To generate that force requires technology on an enormous super-conductive coil. A critical technology requires a large sum of money, particularly in its development phase. Another example is the requirement that the plasma itself be of a certain size in order to prevent it from getting cold through heat conduction. In the case of the JT-60, the plasma is about 60 cubic meters in size, and a power reactor is said to require a plasma of about 400 cubic meters. As the equipment gains in size, the cost of developing it goes up, and the time required for its development gets longer.

A fusion reactor differs from a fission reactor; in the former the energy of neutrons is mainly utilized. The wall material for the blanket that receives the energy and converts it into heat is exposed to bombardment of a high level of neutron irradiation. In Table 1, a neutron wall load of 3.3 MW and neutron irradiation doses of 10 to 20 MW per year per cubic meter are anticipated. An improved stainless steel containing titanium is considered to be a leading candidate for reactor wall material at present. As the history of the nuclear fission reactor reveals, development of a material needs a long lead time. The present stage of fusion reactor development is generally said to be equivalent to the early stage of fission reactor development.



Current priority items		
• Completion of JT-60 at an early time and implementation of a system for its operation and testing Main body completed in April 1985 Heating equipment scheduled for completion in mid-1986 Critical point to be attained in 1987 • High-performance Tokamak Remodeling of JFT-2 Tablet III • Development of tritium handling technology • Development of superconduction technology LCT plan, pulse coil • Research into reactor materials and reactor engineering Development of material irradiation device, bracket engineering • Research into experimental reactor design	o Stability control of self-ignition plasma o Comprehensive demonstration of reactor engineering technology Tritium breeding and mass-handling system Superconductive system Development of nuclear fusion reactor materials Remote-control technology Development of large-size machinery and equipment o Confirmation of engineering safety	o Demonstration of cost effectiveness o Demonstration of reliability o Confirmation of environmental safety

Figure 2. Progress of Nuclear Fusion R&D and Current Priority Items

Limited Fossil Fuel

Energy, along with food, is an indispensable necessity for man. The fossil fuel energy we have been using means that we have been consuming the past legacy of the earth. The recent supply and demand situation in energy is beginning to show signs of loosening, but in the long-term perspective there are limits to fossil fuel. The effect of carbon dioxide, a byproduct of fossil fuel combustion, on world weather is also feared. The unbalanced distribution of fossil fuel resources in the world inevitably gives energy supply

an element of political uncertainty. Japan stands out, at least among the advanced countries, as the land least endowed with natural resources. Consequently, the need to develop the next generation of energy is especially high in Japan, and Japan has great potential to serve the world in the technical development of new energy.

Conceptually, the power reactor shown in Figure 1 has yet to reach the stage of perfection. As to the reactor's commercial feasibility, for example, some people point out that given the general technical experience in recent years, its low power density is a shortcoming in maintaining its economic advantage. The reactor improvement research aimed at raising its power density has so far achieved some success. As to the evaluation of how much energy can be extracted from the reactor, it is calculated that in the case of Figure 1, an amount of energy equivalent to 30 times the thermal energy required to build the reactor can be obtained. Even granting that the estimate on the reactor life and unknown factors in the reactor design may lead to an optimistic conclusion, the value is still meaningful as an index in showing the direction of future R&D.

Since R&D of nuclear fusion includes the development of state-of-the-art technology over a long period of time, there are large ripple effects in society and technology. The EC has succeeded in mobilizing the community's resources in the field of research on nuclear fusion by inaugurating an organic joint development organization, which has resulted in the development of a break even plasma testing apparatus called JET. The success has come to be called a crown in fostering a consciousness of solidarity among the EC countries, and it is performing its role as a precedent to emulate for succeeding joint projects of the EC.

Japan, the United States, and the EC are now in the same league in the field of nuclear fusion research. In the sense that Japan can hold its own in international cooperative projects, the nuclear fusion research at home has grown to be considered one of the highest-level project in the country. Because of the unknown factors associated with nculear fusion R&D, the approach to R&D should always have some room for improvements and/or alternatives. There is little necessity for a single country to conduct all phases of the R&D all by itself. By overcoming the differences in the approach toward R&D that exist among different countries, efforts should be made prudently to insure international cooperation at one time and competition at another.

R&D of nuclear fusion may be said to be the development of systems technology that can be achieved only through the control of rigorous critical conditions. Therefore, this development is expected to have a large ripple effect on other technologies. There is no doubt that the high expectation placed on nuclear fusion technology is a powerful lure for young researchers and engineers. The tendency is for creative researchers and engineers to be bred only in the process of engaging in creative R&D. This experience in nuclear fusion research is a precious one. Who said the Japanese are lacking in creativity? This is totally groundless.

Energy cannot escape from being subject to the prevailing political or economic situation. Recently, however, consumption of energy has come to be increasingly viewed from a moral perspective. We should continue with nuclear fusion R&D and not lose sight of its long-term potential as an attractive energy source.

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DEVELOPMENT OF ROBOTS FOR NUCLEAR ENVIRONMENT DESCRIBED

Robot Technology

Tokyo PUROMETEUSU in Japanese Nov 85 pp 56-57

[Article by Choji Fujii, professor at Tokyo Electrical Engineering College: "Basic Research on Ultimate Work Robots Partially Targeted at Developing Robots Working Under Nuclear Environment"]

[Text] Projects to develop robots to perform tasks such as checks, maintenance, and repair at spots with a high level of radiation within nuclear power plants are underway in several countries led by Japan and France. In Japan, main manufacturers related to the nuclear industry have been individually tackling the matter, while research and development (R&D) of the theme have been pushed as part of the "Ultimate Work Robot," a large project planned by the Agency of Industrial Science and Technology. The project was initiated in fiscal year 1983 on an 8-year plan with the estimated budget of about Y20 billion, with the basic research to be managed mainly by the Electrotechnical Laboratory and the Mechanical Engineering Laboratory, national research institutions, and with development conducted with the cooperation of and partial management by firms concerned belonging to the Ultimate Work Robot Technology Research Association. This article will deal mainly with robots working under nuclear environment.

Robots Working Under Nuclear Environment

Robots working under nuclear environment require functions very different from those of their industrial counterparts. Ordinary industrial robots only perform a kind or several kinds of pretaught works in a fixed environment, and once the work is started, there is no need of human intervention. In this respect, they are autonomous. Also, they are usually installed in an immovable manner, not provided with a free travel capability. So far few of them have incorporated a visual sense or a sense of force.

Meanwhile, robots working under nuclear environment need to be able to respond not only to routine work but also unexpected situations, which makes it necessary for them not only to be autonomous but remotely controlled by an operator or provided with necessary responses to various situations. Also, they will have to travel for work in nuclear power plants where the surface is

not flat as in a factory and they must sometimes step over the piping, climb up and down stairs, or travel vertically along walls. For such work or travel, a visual function is indispensable.

Basic Research Into Ultimate Work Robots

According to the large project news for fiscal year 1983 by the Research and Development Officers' Office, Agency of Industrial Science and Technology, MITI, the basic research into the "ultimate work robot" which has the development of robots working under nuclear environment as one of the important targets, has taken up the following six items: travel technology, manipulation technology, sensor technology, power technology, tele-existence technology, and intellectual remote control technology.

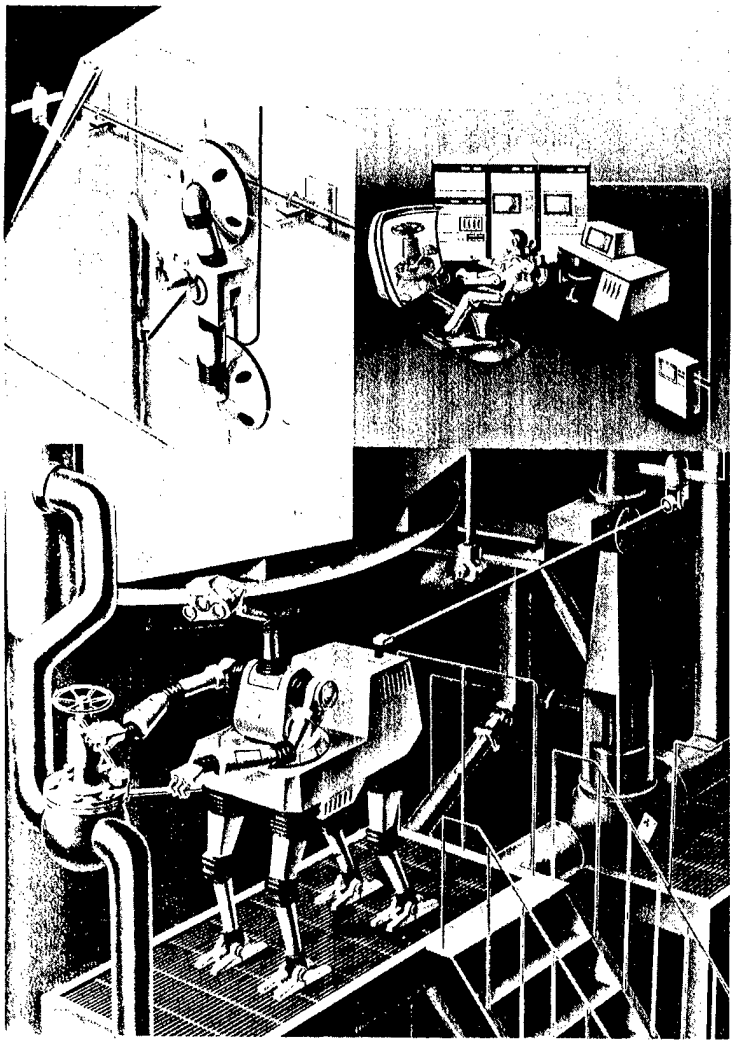
As for travel technology, legs or caterpillar bands are considered for travel over the piping or climbing up and down stairs and suckers are considered for travel along the wall surface, while the research attaches importance to travel by multilegs.

With regard to manipulation technology, R&D will be made of technology of constructing a manipulator capable of controlling force and complicated motions and manipulation technology with an articulated multifinger manpulator. For remotely controlled work at spots with a high level of irradiation, a remotely controlled master-slave manipulator using a bilateral servo mechanism had already been devised in the 1940's, while the current research is targeted at developing a manipulator system by the introduction of a computer which is easy to control and capable of autonomous control even when the master and slave are different in construction.

Tele-existing technology involves permitting an operator to remotely control a robot with the strong sense of being on the spot on a real-time basis as if he were there when he is actually not.

As the target of robots working under nuclear environment, "ultimate work robots," the development of a general purpose robot is considered which is capable of performing quickly and correctly monitoring, checks, and light work in areas difficult for humans to access such as the inside of a containment vessel. The expected work contents include checks, monitoring, and repair work in containment vessels in operation and a number of similar works to be conducted during periodical inspections, such as overhaul and checks of valves and replacement of filters.

The Ultimate Work Robot Technology Research Association has made public a robot having a conceptual image. (See figure on following page: Concept of the ultimate work robot by the R&D Officers' Office, Science and Technology Agency.)



Concept of the Ultimate Work Robot by the R&D Officers' Office, Science and Technology Agency

In the first place, with regard to floor surface travel, it will be conducted by a four-legged walking mechanism provided with perceptual control function capable of walking on the irregular surface, climbing up and down stairs, stepping over the piping and adjusting the height of its legs by folding them. Its action on the wall surface will be made by a travel mechanism linking two negative-pressure suckers.

As for its manipulation, the robot is equipped with a pair of manipulators comprising hands each of which has more than two fingers and arms which are capable of tasks such as overhaul and checks of valves or pumps using machine tools via a remote operator and of displaying considerable autonomous control function for routine work.

As to its perception, it is planned to provide the robot with functions of stereo instrumentation by a visual sense and of detecting infrared rays and irradiation and abilities of monitoring positions of switches and levers, indication of instruments, conditions of equipment and anomalies such as steam leakeage, smoke, oscillation, corrosion, and erosion, of grasping the condition of passages for it to travel along and of identifying objective equipment or machine tools. Also under consideration is providing it with the ability of offering perceptual information which will permit an operator to control it remotely as well as if he were on the spot.

In addition, with regard to its communications, they will be made by the light communication system considering special conditions of nuclear power plants. Concerning its reliability, it is planned to provide it with diagnosis supporting and self-repairing or degenerate functions. Since the robot targeted will have to work under harsh environmental conditions such as irradiation, humidity, and temperature, sufficient consideration, needless to say, should be given to them.

Effects expected when such a robot is realized will be improved efficiency of nuclear power plants by reduction of working and down time, reinforced checks and monitoring, increased possibility of work in areas difficult to access and improved safety and reliability due to reduced exposure. For the highly sophisticated robot shown in this concept, greater efforts in R&D must be made for its perfection. Now that nuclear power is thereby expected to be safer and more efficient, I hope the project will be successful.

New Raw Material

Tokyo PUROMETEUSU in Japanese Nov 85 pp 58-59

[Article by Takayuki Mizuno, general manager, nuclear power furtherance team, R&D Bureau, Electric Power Central Research Institute: "Where To Apply New Raw Materials and Their Candidates for Nuclear Power Plants"]

[Text] Nuclear generated energy has come to account for 24 percent of the entire energy generated, which indicates that we are facing an age where nuclear power dominates over thermal power in power generation. In the initial commercialization period, nuclear power generation used to be bothered by some initial troubles such as stress corrosion cracking in BWR piping

systems and reduced wall thickness in PWR steam generators. However, they were overcome by Japan's intelligence and technological faculty, and reliability of the light water reactor has since rapidly increased. This has resulted in the average plant operation rate of over 70 percent, while there is no increase in the availability factor due to the annual periodical inspection obligated by the law for checks and maintenance of equipment, components, and parts.

In the case of nuclear power generation, since the capital cost such as the construction cost accounts for a high percentage in the generating cost, the improvement in the plant operation rate has great influence on the reduced cost. For this, continuous efforts have been made to prolong on-periods of operation by further improved reliability and longer life of equipment, components and parts and to shorten the period for the periodical inspection by the rationalization of checks and repair. Also remarkable in the material sector is progress in high technology, a number of new materials developed which are superior in physical--thermal and mechanical--stability and chemical stability such as corrosion resistance. By applying these new raw materials to equipment, components and parts in nuclear power plants according to their properties, light water reactor technology can be further sophisticated so as to improve realiability of equipment, components and parts, to improve efficiency in periodical inspections, to prolong the operating period, to improve maintainability of equipment, components and parts, thus permitting reduced exposure of workers and reduced generating cost.

Areas for Spot Application of New Raw Materials

Nuclear power plants can be largely divided into the following three sections: (1) the pressure boundary of the equipment and piping systems to retain primary high-temperature high-pressure water, (2) the actuating system with rotary and bounding parts such as a pump, valve, or turbine, and (3) the auxiliary system such as the sea water system and waste disposal system.

The pressure boundary consists exclusively of metallic materials centering around stainless steel. Metallic materials are, in general, extremely superior in strength, toughness, workability, and connectability and no substitutes for them as materials for large-sized equipment and plants can be found though a number of new materials have been developed.

However, since metallic materials essentially have a great disadvantage that they are not stable in natural environment, especially under hydroenvironment, new raw materials are expected to be applied to special, highly corrosive spots. It will be parts with actuating function such as rotary and bounding ones, it is deemed, that new materials are especially very likely to be applied to. Since parts wear easily at such spots, their periodical checks and replacement are necessary. In nuclear power generation, in particular, no leakage, even slight, of irradiation can be permitted for safety against it, so that application of new materials with surpassing corrosion and wear resistance and low friction and good lubricity, it is deemed, will prolong intervals for checks and replacement of parts, thereby largely contributing to sophistication of light water reactors.

Table of Characteristics of New Raw Materials and Their Applicable Spots

New Raw Material		Characteristics	Disadvantage	Applicable Spot
Fine ceramics		Corrosion resistance, wear resistance, heat resistance	Thermal shock, uniformity of fracture-toughness materials, cost, manufacturing feasibility of large-sized equipment.	Rotary and sealing parts of pumps or valves.
Fine ceramics, coating		Corrosion resistance, wear resistance, heat resistance.	Heat resisting cyclical property, minuteness, adhesive property.	Various piping (especially where strong corrosion resistance is required), pumps, turbine blades.
Metallic materials	Improved materials	Corrosion resistance, wear resistance.	Cost.	Piping in the sea water system, pumps incore equipment, turbines.
	Nonferrous metals	Corrosion resistance.	Connectability, cost.	Turbine blades, etc.
	Amorphous	Corrosion resistance.	Cost, manufacture of large-sized materials, heat resistance.	Equipment under corrosive environmental conditions such as the waste disposal system.
Composite materials		Mechanical strength, wear resistance.	Connectability, cost.	Sealing parts of pumps, turbine blades.
Polymeric materials		Flexibility, corrosion resistance.	Heat resistance, mechanical strength.	Pumps, valves.
Polymeric materials, lining		Corrosion resistance.	Heat resistance, adhesive property.	Tanks, etc.

Also, peripheral equipment for nuclear power generation includes the condenser sea water system which uses a great amount of sea water to condense steam and the waste disposal system to dispose of miscellaneous radioactive waste. These pieces of equipment handle water not so high in temperature and pressure but corrosive due to a greater percentage of salt contained. Materials resistant to spot corrosion are expected to be developed for and applied to them. Also, the sea water system poses troublesome problems of living things such as shellfish attaching to and growing on it and it has long been desired to develop materials which are difficult for them to attach to.

Prospective New Raw Materials

New raw materials expected to be applied to nuclear power plants are: fine ceramics (coating including), metallic materials (improved and new type materials), composite materials (metallic or polymeric materials reinforced by fabric materials), and polymeric materials.

Fine ceramics are the most remarkable in development among current new raw materials, considered to be also promising for use in nuclear power as bearings of pumps and valves and members for sheets or seals due to their surpassing wear resistance and lubricity. However, technology of manufacturing large goods of ceramics has not been sufficiently established yet. Also, ceramics are extremely superior in corrosion resistance, so that possible coating of steel equipment and piping with ceramics is considered to be very useful from the standpoint of their reliability and controlling generation of radioactive corrosion products. Present technology, however, fails to suffice in terms of minuteness in completely coating steel surface and adhesiveness, R&D of which are expected in the future.

As for metallic materials, development is pushed forward with improved type stainless steel, surface treated steel, and composite steel pipes. Concerning nonferrous metals, application of a titanium alloy is likely to increase, while regarding entirely new alloys, a crystal control alloy is likely to be applied to special spots. An amorphous alloy, whose development has just been initiated, is extremely surpassing in corrosion resistance, so that if amorphous treatment for large products or only for the surface becomes possible, it seems to find considerably wide range of applications.

With regard to polymeric materials, interest is taken in their use, including their coating, in corrosive water of the sea water and waste systems. In addition, composite materials reinforced with carbon fibers, etc., have characteristics prospective for use in special spots though they are still rather expensive at present.

In nuclear power generation, the top priority should be given to reliability and safety of plants, so that the abovementioned new raw materials must be applied, based on sufficient corroboration tests. Furthermore, though new raw materials are generally more expensive than their conventional counterparts, the evaluation of their price for their introduction must be made as an ingredient of the total cost considering that they will result in longer life

of products and subsequent reduced cost. With new raw materials, in addition to those mentioned here, a number of functional materials for use in instrumentation and control by optical fiber sensors have been developed.

Superconductive Materials

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[Article by Kyoji Tachikawa, chief of Tsukuba Branch Office, the Research Institute for Metallic Materials: "Application of Superconductivity to Nuclear Power Centering on Nuclear Fusion Reactors and Other Nuclear Sectors"]

[Text] Superconductivity is a phenomenon where electric resistance of a metal becomes totally nil at cryogenic -250 C or below. Under a superconductive condition, an electric current of high density can be flowed without consuming electric power, so that the use of a small amount of power for cooling will permit a strong magnetic field to be generated or electric energy to be stored. Applications of superconductivity cover a wide range from various pieces of electrical equipment to a magnetic-levitation train, NMR/CT system, high energy particle accelerator, and superprecision instrument. Application of superconductivity to nuclear power will play an important role in the nuclear sector centering around a nuclear fusion reactor.

Regarding the nuclear fusion reactor, a magnetic method and an inertial method are studied for confinement of ultrahigh plasma. The magnetic method includes a tokamak and a mirror types, for both of which a large-sized ferromagnetic superconductive magnet is indispensable for a vessel to confine plasma. This is to lessen energy consumed in generating a magnetic field as much as possible so as to take out efficiently energy generated in nuclear fusion reaction as external output. In addition, development is underway of a magnet to generate a magnetic field for induction heating of plasma and a superconductive magnet to be a power source for that which is capable of pulse operation.

With regard to the nuclear fusion reactor of the inertial confinement method, studies are being made of the use of a pulse superconductive magnet for a power source of lasers and electronic beams of great output for instantaneous heating and of MHD power generation using superconductive magnets to convert into electric power energy generated in nuclear fusion reaction. Efforts are also being made for application of superconductivity in the nuclear sector other than nuclear fusion. For example, uranium separators using a large-sized superconductive magnet are manufactured in the United States. Magnetic separation technology utilizing the high gradient magnetic field of a superconductive magnet is likely to result in great progress in nuclear reactor waste disposal technology and concentration technology for low grade uranium ores.

Practical Superconductive Magnet Wire Rods

Superconductive materials employed for nuclear power is used with a view to generating the strong magnetic field. In a superconductive condition, the

temperature, magnetic field and current density have their upper limits called Tc, Hc, and Jc respectively, the higher the critical values of which are, the more advantageous a material becomes practically. Also, when a variable magnetic field covers a superconductive wire, AC loss is caused, which can be lessened by dividing a superconductor in a state of an extremely thin core to be buried in a good conductor such as copper and twisting the wire rod. Practical superconductive materials available at present are an Nb-Ti alloy, A15-type Nb3Sn and V3Ga compounds. An Nb-Ti alloy is superior in workability and needs low cost in manufacturing wire rods, while its wire rods are easy to handle, thus enjoying its widespread use for generating magnetic fields of below 8 tesla (1 telsa = 10,000 gauss). The Nb-Ti superconductive wire manufacturing method involves extruding and wire drawing of a compound material with multiple Nb-Ti alloy cores buried in a copper matrix, thereby making it linear and then heat-treating it for practical use. An Nb-Ti alloy wire rod features little degradation of its superconductive property after undergoing mechanical distortion or neutron irradiation.

In the Large Coil Technology (LCT) furthered under international cooperation, Japan took the initiative in the world in manufacturing a coil with an average diameter of 3-m and total weight of 40 tons. This coil uses a superconductive wire rod with current capacity 20,000 A and a magnetic field of 8 tesla. Also, a study is underway of generating a magnetic field as high as 12 tesla using an Nb-Ti lloy wire rod in superfluid helium (1.8 K) at a lowered working temperature.

For a magnetic field of over 10 tesla to be generated in ordinary liquid helium (4.2 K), it is necessary to use Nb3Sn and V3Ga compounds. However, being extremely hard and brittle in their mechanical properties, these compounds fail to undergo direct wire drawing processing. Extra fine multicore type wire rods of Nb3Sn and V3Ga compounds are manufactured by a manufacturing method called the Bronze Method. This is a method involving making a compound material linear which has a number of Nb (V) rods fitted in a Cu-Sn (Cu-Ga) alloy matrix linear by extrusion and wire drawing, heat treatment after drawing and creating Nb3Sn (V3Ga) extra fine cores showing excellent superconductive characteristics by solid diffusion of Nb (V) extra fine cores and Sn (Ga) within the matrix.

Recently it has been found that an Nb3Sn extra fine multicore wire made from Ti-added bronze not only improves strong magnetic field characteristics but results in less degraded superconductivity against distortion added, which has led to its industrialization. A Ti-added Nb3Sn extra fine multicore wire shows HC2 of 25 tesla at 4.2 K (-269 C), and generation of a 15-tesla magnetic field using a wire rod of the same has been demonstrated. A wire rod of this kind, along with a VsGa extra fine multicore wire, is most excellent in strong magnetic field characteristics as an extra fine multicore type wire rod available at present. A great quantity of Ti-added Nb3Sn wire rods developed in Japan will be used for MFTF-B, the United States' world largest tandem mirror type nuclear fusion equipment.

New Superconductive Wire Rods

What is desirable as a practical superconductive magnet material for nuclear fusion reactors is one with a high superconduction critical value whose superconductive characteristics will not degrade against neutron irradiation or distortion. As such new superconductive materials, there are B1 type NbN group compounds and Laves type V2Hf group compounds. Of them, with V2 (HfZr) compounds invented in Japan, a compound material of a V matrix and Zr-Hf alloy core undergoes wire drawing and is processed into extra fine multicore wire by diffuse heat treatment. Strong magnetic field characteristics of a V2 (Hf, Zr) extra fine multicore wire are of the same level as an Nb3Sn counterpart.

Also, when an extremely high magnetic field of over 20 tesla becomes necessary in nuclear fusion reactors in the future, it would be desired to make available wire rods of new materials with Hc2 of 30-50 tesla, such as compounds of A15 type Nb3Aℓ, Nb3 (Aℓ, Ge) and Nb3Ge and (Schrabel) type PbMo6S8 compounds. At present it is being studied to manufacture wire rods of these compounds by liquid quenching, powder, and evaporation methods.

In the meantime, with regard to superconductive magnet wire rods capable of pulse operation, a study is being made of the sectional structure with barriers of high electric resistance inserted between cores in order to control a combined current flowing between superconductive cores which causes AC loss as small as possible. It was reported recently that an Nb-Ti superextra fine core wire for pulse operation with a core diameter of below 1 μm was experimentally manufactured, which was available by commercial frequencies. However, since wire rods in this application without fail cause exothermic, compound wire rods with high Tc would be more advantageous.

At present, technology of manufacturing 8-tesla class large superconductive magnets using Nb-Ti alloy wire rods, as in the example of the LCT coil, is nearing its completion. In addition, for stronger 15-tesla class large superconductive magnets, Ti-added Nb3Sn wire rods will be put into practical use, thereby responding to nuclear fusion equipment with stronger magnetic fields. Besides, R&D is underway of superconductive wire rods capable of pulse operation, those capable of generating magnetic fields of over 20 tesla.

Great progress is being made in superconductivity large application technology as in the case of the SSC project (superlarge accelerator with a circumference of 100-km) recently initiated in the United States. For this, the development of relevant technologies such as efficient refrigerating and cooling technology and cryogenic structural materials with high reliability will play an important role. Also, in the field of superconductive materials, superconductive magnets, and cryogenic structural materials, close international cooperation as well as Japan-U.S. cooperation have been pushed, thus contributing to the raised level of information internationally.

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