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No. 37

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USSR AND EASTERN EUROPE SCIENTIFIC ABSTRACTS

PHYSICS AND MATHEMATICS

No. 37

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USSR

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RADIATIVE DECAY OF DIRECT AND INDIRECT EXCITONS IN GaSe AT LOW TEMPERATURES

Leningrad FIZIKA I TEKHNICA POLUPROVODNIKOV in Russian Vol 11 No 5, May 77
pp 859-866 manuscript received 27 Sep 76

BELENK'KIY, G. L., GODZHAYEV, M. O., NANI, R. KH., SALAYEV, E. YU., and
SULEYMANOV, R. A., Institute of Physics, Academy of Science Az SSR, Baku

[Abstract] Results are presented from pulverization studies of the photoluminescence spectra of GaSe, recorded from various natural crystalline facets. The temperature dependence of the intensity of various lines (4.2-50 K) and the influence of uniaxial compression (up to 30 bar) on the positions of these lines in the spectra were studied. A model is suggested for the energy state near the absorption edge of GaSe, within the framework of which it is possible to explain the experimental data observed by these and other authors. A possible mechanism is suggested for the radiation observed at high levels of excitation, consisting in the elastic interaction of indirect excitons. In GaSe, it is suggested, in addition to the direct exciton band located some 20 meV below the conduction band, there is a band of indirect excitons with a binding energy of 43 meV. An energy diagram is given. References 17: 8 Russian, 9 Western.

USSR

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TEMPERATURE VARIATION IN THE WIDTH OF THE FORBIDDEN BAND OF SOLID SOLUTIONS OF $\text{In}_{1-x}\text{Ga}_x\text{P}$ WHEN $x \leq 0.5$

Leningrad FIZIKA I TEKHNICA POLUPROVODNIKOV in Russian Vol 11 No 5, May 77
pp 997-999 manuscript received 9 Dec 76

VOLKOV, L. A., KOVALENKO, V. F., MARONCHUK, I. YE., and SHEPEL', L. G., Kirovograd State Pedagogic Institute imeni A. S. Pushkin

[Abstract] Measurements were performed of the width of the direct forbidden band in $\text{In}_{1-x}\text{Ga}_x\text{P}$ ($x \leq 0.5$) by the photoluminescent method in the 77-300 K zone in order to determine the precise value of the temperature coefficient with various values of x . The measurements were performed using specially undoped layers of $n\text{-In}_{1-x}\text{Ga}_x\text{P}$, produced by liquid epitaxy from a limited volume of solution-melt on GaAs substrates. The temperature variation of x_c determined by the points of intersection of curves $E_g(\rho_{15} - \rho_1)$ and $E_g(\rho_{15} - X_1)$ at 377 K, is $x_c \approx 0.04$ mol. %, i.e., $x_{c,300} = x_{c,77} + 0.04$. The results indicate that the transition point x_c in solid solutions of $\text{In}_{1-x}\text{Ga}_x\text{P}$ depends on temperature. References 12: 4 Russian, 8 Western.

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MECHANISM OF NONRADIATIVE RECOMBINATION OF CHARGE CARRIERS IN LOW-RESISTANCE CdSe CRYSTALS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 11 No 5, May 77 pp 955-961 manuscript received 9 Dec 76

LYUBCHENKO, A. V., FEDOROV, A. I., and SHEINKMAN, M. K., Institute of Semiconductors, Academy of Science UkSSR, Kiev

[Abstract] A study is made of the steady and kinetic characteristics of photocurrent and photoluminescence of CdSe single crystals with various deviations from stoichiometric composition when the concentration of equilibrium electrons is 10^{14} - 10^{17} cm⁻³ in the 10-400 K temperature interval. During the study of recombination in low-resistance CdSe crystals, a number of peculiarities were discovered in the characteristics of photocurrent and photoluminescence which can be considered direct results of impact Auger interactions of carriers bound at centers of nonradiative recombination. Edge radiation with $h\nu_m = 1.74$ eV was detected at 10 K. It is shown that this radiation arises upon electron transition in a donor-acceptor pair; the quantum yield of luminescence is significantly reduced by the nonradiative recombination channel. In the area of temperatures above 350 K, thermal activation of photoluminescence and photocurrent are detected, and shown to result from a decrease in the probability of nonradiative transition in the luminous center itself (Auger). It is demonstrated that nonradiative recombination centers have an electron capture cross section comparable to that of radiative centers. These centers may be centers of photosensitivity in the semiconductor. References 15: 13 Russian, 2 Western.

USSR

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STUDY OF THE EFFECT OF GAMMA QUANTA ON p-Si DOPED WITH IRON

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 11 No 5, May 77 pp 951-954 manuscript received 8 Dec 76

DYATLOV, A. I., KAPITONOVA, L. M., LEBEDEV, A. A., POGARSKIY, M. A., and SHAPOSHNIKOVA, T. A., Institute of Physics and Technology imeni A. F. Ioffe, Academy of Sciences USSR, Leningrad

[Abstract] A study was made of the results of the action of gamma quanta on p-Si doped with Fe by means of a photocapacitive method. The variation of concentration of impurity centers, as well as the total concentration of charged centers in the space charge layer with radiation dose and temperature of subsequent isochronic annealing in the 50-300°C range were determined. It was found that as the radiation dose increases, the process of alteration of the concentration of impurity centers flows smoothly. Gamma quanta produced primarily the levels $E_v + 0.4$ eV, which have a relatively great capture

cross section for protons by the k_n electron. During the course of irradiation, the concentration of nonphotoactive donor centers increases; the iron atoms participate in the formation of these centers. The decrease in the value of ΔN in the process of isochronic annealing apparently results from restructuring of existing defects in the material under the influence of heat. References 7: 6 Russian, 1 Western.

USSR

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ELECTRIC AND PHOTOELECTRIC PROPERTIES OF THE TRANSITION REGION BETWEEN SILICON AND A Ge-Si SOLID SOLUTION

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 11 No 5, May 77 pp 923-928 manuscript received 12 Nov 76

IBRAGIMOV, R. SH., KLIMENKO, E. A., LOVYAGIN, R. N., and KLIMENKO, A. G., Institute of Semiconductor Physics, Siberian Affiliate, Academy of Sciences USSR, Novosibirsk

[Abstract] A study is made of the electric and photoelectric properties of diodes in specimens which consist of a silicon plus Ge-Si solid solution structure. The method of manufacture consists in attachment of a silicon disc to the ceramic through a thin intermediate layer of germanium-silicon solid solution. Both of these layers are over a nonoriented insulating substrate (mullite $Al_2O_3+SiO_2$). Analysis of the conditions of production and calculations are used to establish the structure of the diodes and construct an energy diagram. According to this diagram, the diode in question consists of 2 series-connected junctions; one isotypic p-p heterojunction formed as a result of crystallization of the Ge-Si solution on the silicon, the other ordinary p-n junction formed in the silicon by diffusion of aluminum. Measurements of the current-voltage and capacitance-voltage characteristics shows that the electric properties of the structure are determined by the ordinary p-n junction in the silicon and are well described by the theory of Noyce and Shockley. Measurements of the spectral photosensitivity of the diode are performed, using the window effect, allowing charge carriers to be generated in the Ge-Si solution, which has a narrower forbidden band than does the silicon upon illumination on the silicon side. The studies prove the possibility in principle of expanding the spectral area of the photoresponse of ordinary p-n junctions formed in a broad-band material by generation of charge carriers in a narrow-band semiconductor grown on one of the areas of the p-n junction. This allows the dark current to be decreased, consequently increasing the relative sensitivity of the photodetector. References 13: 9 Russian, 4 Western.

ANOMALOUS ELECTRICAL PROPERTIES OF LAYERS OF $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ WITH INDIUM DOPANT

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 11 No 5, May 77
pp 846-854 manuscript received 17 Aug 76

GEYMAN, K. I., DRABKIN, I. A., MATVEYENKO, A. V., MOZHAYEV, YE. A., and
PARFEN'YEV, R. V., Institute of Physics and Technology imeni A. F. Ioffe,
Academy of Sciences USSR, Leningrad

[Abstract] A study was made of the galvanomagnetic properties of indium-doped single crystal layers of $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ of N type, atomized onto chips of BaF_2 . Layers with In had high homogeneity and lower electron concentration of 77 K than layers without In. When the temperature was lowered to below 20 K in layers of $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ with In, an anomalous sharp increase in the concentration of electrons as calculated from the Hall coefficient was observed along with a decrease in electron mobility. This phenomenon may be related to the behavior of the indium under conditions of a possible structural phase transition initiated by the adding tin to the PbTe. Study of Shubnikov-de Haas oscillations confirmed the anomalous temperature variation of electron concentration. Peculiarities in the oscillations in $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ layers with In and without In were detected, evoked by deformations in the films resulting in differences in the coefficients of linear expansion of material and substrate. The splitting energy in the conduction band of these layers of $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ is defined and the deformation potential shift constant estimated. The displacements of the Sn^{2+} ions and the resultant displacements of indium ions average out differently in a film than in a three-dimensional crystal, where the averaging occurs in the four equivalent directions of [111] polarization. However, this assumption requires testing in experiments on the uniaxial deformation of $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ crystals with In; it should be noted that these crystals without In show no significant changes in band structure in the 4.2-20 K temperature interval. The displacements in [111] related to the structural transition are therefore small in comparison to displacements in the film due to the difference in coefficients of linear expansion between film and substrate, and only due to the presence of the indium is it possible to detect the transition. References 18: 11 Russian, 7 Western.

USSR

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OPTICAL SPECTRA AND BAND STRUCTURE OF CdGa_2Se_4 AND CdGa_2S_4 SINGLE CRYSTALS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 11 No 6, 1977 pp 1135-1142 manuscript received 1 Mar 76 after correction 23 Dec 76

GUSEYNOVA, D. A., KERIMOVA, T. G., and NANI, R. KH., Azerbaydzhan SSR Academy of Sciences Institute of Physics, Baku

[Abstract] It is possible to make a quantitative determination of the band structure of crystals by studying their reflection and absorption spectra if there are available theoretical calculations of the energy spectrum of electrons in crystals with a similar structure. In this paper an attempt is made to interpret the reflection and absorption spectra of CdGa_2Se_4 and CdGa_2S_4 , belonging to class $A^{II}B_2^{III}C_4^{VI}$, based on a theoretical group analysis made for compounds which crystallize with a thiogallate structure, and on an analysis of reflection spectra of their closest isoelectronic analogs. Absorption and reflection spectra are studied in the 2 to 6 eV region in natural and polarized light. The theoretical group analysis makes it possible to classify electron states and determine the frequency of band degeneration at symmetrical points in the Brillouin zone. Rules of selection are determined for dipole transitions both with and without taking electron spin into account. Compatibility equations are obtained which indicate changes in the symmetry of states and in their degeneration when going from a more highly symmetric point in the Brillouin zone to a less symmetric. The band structures of CdGa_2Se_4 and CdGa_2S_4 are derived from the band structures of ZnGeAs_2 and ZnGeP_2 , respectively, compounds of the $A^{II}B^{IV}C_2^V$ type, and their nearest isoelectronic analogs. Figures 4; tables 7; references 10: 6 Russian, 4 Western.

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LUMINESCENT PROPERTIES OF FILMS OF $\text{In}_{1-x}\text{Ga}_x\text{P}$ ($0.6 \leq x \leq 0.7$) OBTAINED BY LIQUID EPITAXY ON $\text{GaAs}_{1-y}\text{P}_y$ SUBSTRATES

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 11 No 6, 1977 pp 1102-1107 manuscript received 18 Aug 76 after correction 12 Dec 76

YERMAKOV, O. N., IGNATKINA, R. S., SUSHKOV, V. P., and CHUKICHEV, M. V.

[Abstract] Indium phosphide - gallium phosphide ($\text{In}_{1-x}\text{Ga}_x\text{P}$) solid solutions are promising materials for creating sources of spontaneous and coherent radiation operating over a wide spectrum range from the IR to the yellow-green region, since optical crossover transitions are possible in $\text{In}_{1-x}\text{Ga}_x\text{P}$ at least up to an electric field strength of 2.14 eV. The fact that GaP and InP have

different lattice constants creates difficulties in liquid epitaxy of single-crystal films of $\text{In}_{1-x}\text{Ga}_x\text{P}$. With $\text{In}_{1-x}\text{Ga}_x\text{P}$ films of medium composition, where $x = 0.6$ to 0.7 , it is possible to use substrates of $\text{GaAs}_{1-y}\text{P}_y$ solid solutions, for when $x = 0.48y + 0.52$ the lattice constants of the film and substrate agree. This paper presents data on obtaining films of $\text{In}_{1-x}\text{Ga}_x\text{P}$ ($0.6 \leq x \leq 0.7$) grown by the liquid epitaxy method on substrates of $\text{GaAs}_{1-y}\text{P}_y$ ($0.2 \leq y \leq 0.4$) oriented in plane (111)-B, and on the results of studying photoluminescence and cathodoluminescence of these films. A study is made of the spectral distribution of photoluminescence and cathodoluminescence of n-type and p-type films in the 65 to 300 K range under different conditions of excitation. Band-band radiative recombination takes part in formation of line A, and line B in the luminescence spectra of specially undoped $\text{In}_{1-x}\text{Ga}_x\text{P}$ is associated with recombination via an uncontrollable acceptor center. Line C in the cathodoluminescence spectra of $\text{In}_{1-x}\text{Ga}_x\text{P}$ doped with zinc and tellurium is attributed to donor-acceptor recombination. A determination is made of the extrinsic quantum yield of cathodoluminescence of n-type (specially undoped) and p-type (doped with zinc and tellurium) $\text{In}_{0.38}\text{Ga}_{0.67}\text{P}$ films at 300 K. This was accomplished by means of a Cameca microanalyzer, by establishing the ratio between the number of quanta emitted beyond the boundaries of the specimen per unit of time to the number of nonequilibrium electron-hole pairs generated per unit of time. Figures 6; references 9: 2 Russian, 7 Western.

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TRANSITION TO THE GAPLESS STATE UNDER THE EFFECT OF PRESSURE IN A $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ ALLOY DOPED WITH INDIUM

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 11 No 6, 1977 pp 1077-1083 manuscript received 2 Dec 76

AKIMOV, B. A., VADKHVA, R. S., ZLOMANOV, V. P., RYABOVA, L. I., and CHUDINOV, S. M., Moscow State University imeni M. V. Lomonosov

[Abstract] This paper is devoted to a study of galvanomagnetic and oscillation effects in a $\text{Pb}_{0.78}\text{Sn}_{0.22}\text{Te}$ alloy doped with 0.5 at .% indium in the transition to the gapless state under the effect of hydrostatic compression not exceeding 16 kbars. Measurements were made of two specimens of this alloy cleaved along axes [100] and [110] in magnetic fields not exceeding $3.2 \cdot 10^6$ A/m at helium temperatures. A characteristic feature of the transition to the gapless state in an n-type or p-type $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ alloy under pressure is that this transition takes place with a steady concentration of current carriers. An alloy of this type with an In impurity not exceeding 1 at .% is interesting to study from the viewpoint of the transition to the gapless state because a stable position

of the Fermi level practically independent of the indium concentration is characteristic of these materials. This position is also independent of the content of other donor or acceptor impurities if their concentration does not exceed that of the indium concentration. It is demonstrated here that the concentration of current carriers increases under pressure and reaches a maximum at the band inversion point when hydrostatic compression roughly equals P_i , and the magnitude of effective mass at the Fermi level remains practically constant. The experimental data obtained here are used to construct a diagram of the shift in energy levels under the effect of pressure, and a determination is also made of the value of the pressure coefficient of the forbidden band ($\partial \epsilon_g / \partial P$). The magnitude of the energy gap, ϵ_g , and the position of the impurity band are calculated when the pressure is zero. The magnetic field was created with a Hemholtz design superconducting magnet with the magnetic field perpendicular to the measuring current running through the specimen (grown by the Czochralski method). Curves are given, showing the dependence of resistivity on pressure, the relationship between pressure and Hall concentration, and the relationship between cross sections of the Fermi electronic surface with the magnetic field parallel to [100] under pressure at 4.2 K. Figures 5; references 9: 5 Russian, 4 Western.

USSR

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IMPURITY PHOTOCONDUCTIVITY OF GaAs<0> IN STRONG ELECTRIC FIELDS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 11 No 6, 1977 pp 1049-1054 manuscript received 29 Mar 76, after correction 15 Nov 76

BRODOVOY, V. A., DERIKOT, N. Z., and VAKULENKO, O. V., Kiev State University imeni T. G. Shevchenko

[Abstract] This paper gives the results of a study of impurity photoconductivity of GaAs compensated with oxygen in the photon energy region of 0.4 to 0.7 eV with different electric field strengths. Studies of photoconductivity in the IR region of the spectrum in strong electric fields make it possible to obtain supplementary data on the properties of deep levels produced by added elements. A study was made of single crystals of GaAs compensated with oxygen with n-type conduction. Specimens were parallelepipeds measuring 1 X 0.5 X 0.5 mm. Indium contacts were applied to end faces. An IKS-12 monochromator was used to measure impurity photoconductivity spectra. Lighting was provided with a globar with 200-Hz modulation set away from the monochromator and focused on the specimen by means of spherical mirrors. The specimen was placed in a cryostat with calcium fluoride windows. The photoresponse signal was recorded by means of a load resistance connected in series with the specimen.

All measurements were made at 90 K in the region of linear lux-ampere characteristics. The compensation method was used to study the kinetics of impurity photoconductivity, and a block diagram of the instrument setup used for this purpose is presented. This method, utilizing a photomultiplier, narrowband amplifier, and an oscilloscope in conjunction with a subtractor and integrator, made it possible to measure time constants in the 1.3×10^{-6} to 10^{-2} s range. Impurity photoconductivity within the proton energy region studied is n-type. Photocurrent volt-ampere characteristics (PVAC's) plotted in the region of the impurity photoconductivity maximum with low-strength electric fields were linear. Starting with a field of 2.5×10^3 V/cm, PVAC's became ultralinear. The maximum and longwave limit of photoconductivity shift with an increase in field strength in the direction of lower photon energy. The photoelectric energy for ionization of the impurity center is reduced linearly with an increase in electric field strength. The influence of the electric field on the nature of impurity photoconductivity can be explained both by a reduction in the depth of the potential well of the impurity center and an increase in the rate of thermal ionization, and by impact ionization of optically excited impurity atoms. The luxampere characteristics observed here over a wide voltage range indicate that impact ionization does not play a determining role here. The ultralinear nature of PVAC's observed here is caused by thermal field ionization. A model of electron transitions is offered to explain the form of PVAC's observed and the shift in the longwave limit of photoconductivity. A theoretical analysis is made of the dependence of the lifetime of photoelectrons on the electric field strength. Figures 4; references 10: 7 Russian, 3 Western.

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USSR

ANISOTROPIC PHOTOCONDUCTIVITY OF HgGa_2Se_4 SINGLE CRYSTALS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 11 No 6, 1977 pp 1038-1042 manuscript received 4 Oct 76

LEBEDEV, A. A., METLINSKIY, P. N., RUD', YU. V., and TYRZIU, V. G., USSR Academy of Sciences Physics and Engineering Institute imeni A. F. Ioffe, Leningrad, and Kishinev Polytechnical Institute imeni S. Lazo

[Abstract] This paper gives the results of a study of the photoconductivity of a crystal of a compound of the $\text{A}^{\text{II}}\text{B}^{\text{III}}\text{C}_4^{\text{VI}}$ type, HgGa_2Se_4 , in polarized light. These compounds have been studied but little and have a thiogallate crystal lattice (S_4^{2-}). Semiconductors with an anisotropic energy spectrum make it possible to create devices with completely new functional capabilities. A previous study indicated that HgGa_2Se_4 is an n-type semiconductor which is insensitive to polarized light. A study was made of crystals grown by the gas transport reaction method and having a reflecting surface developed to the

maximum (001). Measurements of photoconductivity spectra were made using photosensitive crystals with steady or 30-Hz modulated lighting from an SPM-2 monochromator with an SiO₂ prism at 77 and 300 K in the 1 to 4 eV region of the spectrum. A PF-42 polaroid was used to divide the light with a known position of the electrical vector. Photoresponse was proportional to the flux density of the incident light. Photoconductivity spectra are shown for a typical specimen in natural light. Photosensitivity is observed in this crystal at 300 K over a wide region of the spectrum from 1 to 4 eV. The structure of photoconductivity spectra in the region of roughly 1.6 eV is critically dependent on the geometry of lighting. Features of these spectra are discussed in detail. Typical spectra are also shown for a crystal in polarized light. The pleochroism spectrum was computed for a crystal of HgGa₂Se₄ from measurements of photoconductivity in polarized light. It is demonstrated that this compound is a highly photosensitive uniaxial n-type crystal with positive pleochroism ($P \sim 0.6$). Crystals are encountered in which P approaches zero. This is associated with twinning, and a specimen sensitive to polarization can only be made from a crystal of this type by appropriate grinding. This situation probably explains the results achieved in the previous study indicating that HgGa₂Se₄ is insensitive to polarization. It is concluded that crystals of HgGa₂Se₄ can be used as highly sensitive photoresistors for natural light in the visible and UV regions of the spectrum, and also as photoelectric analyzers for linearly polarized light at roughly 1.5 eV or more. Positive uniaxial crystals of this class can also be of interest for nonlinear optics. Figures 3; references 9: 7 Russian, 2 Western.

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ELLIPSOMETRIC STUDY OF THE SURFACE OF SILICON DOPED WITH SILVER

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 11 No 6, 1977 pp 1026-1032 manuscript received 29 Sep 76

TYAGAY, V. A., SNITKO, O. V., RASTRENENKO, N. A., MILENIN, V. V., POLUDIN, V. I., and PRIMACHENKO, V. YE., Ukrainian SSR Academy of Sciences Institute of Semiconductors, Kiev

[Abstract] Ellipsometry, one of the most precise methods of studying a surface and thin surface films, is applied here to studying surface doping of semiconductors with impurity metals, of a silicon surface doped with silver, in particular. Ellipsometry can be a convenient method of determining the optical properties of a junction-type surface film and yield important data on the amount

of impurity added and its distribution over the surface, as well as on the physical properties of the doped surface closely allied with the semiconductor's surface state spectrum. The study made here was carried out with a spectrum ellipsometer developed by the authors and providing for smooth resetting of the wavelength over the 0.4 to 0.8 μm range. A study was made of the surface of p-type silicon with orientation (111), which was doped by soaking the specimen for two minutes in a solution of hydrofluoric acid containing an addition of silver nitrate. The surface was pretreated by grinding and polishing with diamond paste abrasives and by chemical etching. Results of ellipsometric measurements were compared with data on the morphology of metallic coatings of silver on silicon which was obtained with an electron microscope by the method of carbon-and-platinum replicas with extraction of silver. Curves are given showing the relationship of major ellipsometric parameters to the angle of incidence, the concentration of the doping impurity in the solution, and the wavelength. Features of these relationships are discussed in detail. A study of the nature of the inhomogeneity of the surface from the optical standpoint was made by analyzing electron microscope photos. Diffraction of fast electrons demonstrated that the islets of the metallic coating are single crystals with a lattice parameter characteristic of elemental silver and which have a chaotic orientation relative to the surface of the silicon substrate. Comparisons are made between these data and ellipsometric curves. A study was also made of the influence of the microrelief of the substrate on ellipsometric parameters, by studying the properties of the silicon surface after removing the metallic coating by dissolving it in concentrated HNO_3 . A structural and electrophysical model of a doped silicon surface is offered, reflecting the specific features of deposition of the impurity and its distribution over the surface. This model is used to advance hypotheses on a number of aspects of optical and electrophysical properties, such as resonance of surface plasmons and variation in the surface level spectrum. Measurements were made for the first time of the dispersion in ellipsometric parameters to determine the resonance of surface plasmons for a doped surface. Resonance features are lacking in the plasma resonance region of silver microparticles. It is demonstrated that ellipsometric data can be used successfully for monitoring the extent of coating and the morphology of surface structures which originate in doping. Figures 5; tables 1; references 9; 5 Russian, 4 Western.

FEATURES OF THE CONDUCTIVITY OF SEMI-INSULATING SiC IN STRONG ELECTRIC FIELDS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 11 No 6, 1977 pp 1022-1025 manuscript received 6 Jul 76

BRODOVOY, V. A., GOZAK, A. CH., and PEKA, G. P., Kiev State University imeni T. G. Shevchenko

[Abstract] This paper is devoted to a study of the role of deep capture levels in formation of the S-type volt-ampere characteristic of asymmetric diode structures based on semi-insulating SiC at low current density. A study is also made of the phenomenon of long-term storage of residual (induced) conductivity, i.e., of the situation in which the crystal goes into the low-ohmic state after sufficiently high current density is passed through it. Specimens studied were of n-type SiC with an injecting point contact made of phosphor-bronze and an indium ohmic contact. In forward biasing an S-type volt-ampere characteristic is observed owing to modulation of the resistance of the high-ohmic base according to the "tau" mechanism described in an earlier study. According to this mechanism, modulation of the resistance of the high-ohmic base is associated with accumulation of injected minority carriers at deep impurity centers with capture cross section asymmetry (r-centers). The cut-in voltage is determined by initial filling of r-centers. If deep capture levels for electrons are present in sufficient concentration in the crystal in addition to r-centers, it is possible to control r-centers by filling these levels and thus influence the shape of the volt-ampere characteristic. The nature of this characteristic and the cutoff voltage depend substantially on the degree of charge transfer of deep r- and t-levels, and it is possible to control the form of the volt-ampere characteristic and switching parameters by reverse relocalization of electrons from t-levels to r-centers by field, thermal, and photo-ionization. Measurements were made of the volt-ampere characteristic in the steady state after repeatedly cutting on in the transfer direction, as well as after applying a strong electric field to the structure, which causes ionization of t-levels. Direct data on filling of capture levels and on the change in filling in strong fields is obtained by studying heat-stimulated conductivity spectra while measuring the volt-ampere characteristic. An experimental demonstration is given of the relationship between the extent to which t-levels are filled and the cutoff voltage, confirming the mechanism for field control of the volt-ampere characteristic suggested here. Residual conductivity (RC) is observed in the SiC crystals studied here after they are "switched on" under high current density conditions. This effect is determined by preliminary injection, and not by light excitation, although a common mechanism for both these phenomena was suggested in an earlier study, using a model for RC based on the presence of a collective barrier at many recombination centers in combination with the low-ohmic film of the semiconductor. The abrupt reduction in the resistance of the specimens studied here in reverse biasing resulting in symmetry of the volt-ampere characteristic is explained by reduction of the thickness of this barrier at the point contact under RC conditions. Figures 3; references 7: 6 Russian, 1 Western.

MECHANISM OF CHANGE IN THE WIDTH OF THE FORBIDDEN BAND IN HEAVILY DOPED GALLIUM ARSENIDE

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 11 No 6, 1977 pp 1017-1021 manuscript received 5 Apr 76

ZVEREV, L. P., NEGASHEV, S. A., KRUSHAYEV, V. V., and MIN'KOV, G. M., Ural State University imeni A. M. Gor'kiy, Sverdlovsk

[Abstract] A previous study by these investigators gave the preliminary results of determining the width of the forbidden band of heavily doped n-GaAs by the OMA [oscillating magnetic absorption] method. The effective width of the forbidden band, E_g , is determined as the energy gap obtained as the result of extrapolating to a zero value of the magnetic field the distance between Landau levels of the conduction and valence band. This paper gives the results of a broader study of OMA in both n-type and p-type GaAs, as well as of heavily doped compensated GaAs. Specimens which were not specially compensated were doped with tellurium and zinc, and their level of compensation was no higher than 20 to 30 percent. Heavily doped n-type and p-type material was compensated by diffusion of copper at 950°C and lithium at 1050°C. A study was also made of OMA spectra of several specimens obtained by exposing n-type material to electrons with energy of 2 MeV. OMA was observed in both types of GaAs throughout the entire doping range studied. Measurements were made using a Faraday configuration (electric field perpendicular to magnetic) at 77 ° with a magnetic field strength not exceeding $2.5 \cdot 10^7$ A/m. Curves are derived, showing the relationship between magnetic absorption maxima and the magnetic field strength before and after compensation. It was demonstrated that the effective width of the forbidden band of a heavily compensated material based on n-type GaAs depends but slightly on the impurity concentration. The data given here demonstrates that in heavily doped p-type material E_g practically does not depend on the impurity concentration and is determined by the concentration of free carriers. The conclusion is made that interaction between carriers and the impurity potential does not result in a substantial change in the width of the forbidden band of heavily doped GaAs, but that exchange-type interaction of free carriers makes the basic contribution to the reduction in E_g of uncompensated GaAs when doped, as observed here. Figures 3; tables 1; references 22: 18 Russian, 4 Western.

TUNNEL CURRENT IN GaAs p-n JUNCTIONS AS A FUNCTION OF MECHANICAL STRESS

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY, FIZIKA in Russian No 3, 1977 pp 134-139 manuscript received 7 Jul 76

VYATKIN, A. P., and KRIVOROTOV, N. P., Siberian Physics and Engineering Institute imeni V. D. Kuznetsov at Tomsk State University

[Abstract] This paper deals with calculating the tunnel current sensitivity to shearing strains in tunnel p-n junctions of gallium arsenide. This calculation technique uses the approximation of high hole energies, where $|E - E_v| \gg \delta$, where δ represents the energy splitting of light and heavy hole branches at the center of the Brillouin zone caused by the effect of shearing strains. Previous studies utilized an approximation of low hole energies, where $|E - E_v| \ll \delta$, and this is demonstrated to be incorrect here. The relationship between the tunnel current and shearing strains was also determined experimentally, by exerting uniaxial and hydrostatic pressure on a p-n junction. Hydrostatic pressure was exerted by kerosene oil in a piston and cylinder pressure chamber. Uniaxial pressure (compression) was exerted with a steel pin and metal washer. Comparison between calculated and experimental data demonstrates the greater accuracy of the approximations made here. A curve is derived, expressing the relationship between the coefficient of tunnel current under mechanical stress for tunneling along plane [111] and for pressure along [110], and the bias voltage in the p-n junction. Experimental and calculated curves for this relationship are compared. There is an exponential relationship between the static factor and the bias voltage; the good agreement of calculated and experimental results proves that the static factor makes a fundamental contribution to the shear-related piezoelectric effect. This conclusion confirms the initial hypothesis that the shear-related piezoelectric effect of the tunnel current must be dependent only on the thickness of the p-n junction and the static factor. Figures 2; references 12: 6 Russian, 6 Western.

STUDY OF SOME PHYSICAL PROPERTIES OF SINGLE CRYSTALS OF GaAs AND $\text{Al}_x\text{Ga}_{1-x}\text{As}$
SOLID SOLUTIONS BY THE METHOD OF PHOTO- AND CATHODE LUMINESCENCE

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY, FIZIKA in Russian No 3, 1977 pp 117-121 manuscript received 7 Jun 76, after correction 24 Aug 76

KEDA, A. I., LUNIN, L. S., and LUNINA, O. D., Novocherkassk Polytechnical Institute

[Abstract] In this paper studies are made of the photo- and cathode luminescence spectra of epitaxial films of GaAs and $\text{Al}_x\text{Ga}_{1-x}\text{As}$ solid solutions grown by the method of zone recrystallization using a temperature gradient. Studies are made of such physical characteristics as impurity concentration, its distribution, width of the forbidden band, and the activation energy of donors and acceptors. The concentration of AlAs varied from 0 to 30 molar percent, solid solutions of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ being grown on GaAs substrates, both n-type and p-type. Curves were obtained, expressing the distribution of the concentration of Te, Ge, and Zn dopants throughout the depth of epitaxial films of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ solid solutions and gallium arsenide. It is demonstrated that Al has an influence on the distribution factor for Ge in $\text{Al}_x\text{Ga}_{1-x}\text{As}$. As the amount of aluminum in the melt increases the segregation coefficient of germanium decreases, resulting in a reduction in the concentration of Ge in $\text{Al}_x\text{Ga}_{1-x}\text{As}$. Reducing the concentration of Al results in increasing that of Ge. A table is given which shows the influence of Al on the distribution factor for Te and Zn as well. Another table is given showing the relationship between the depth of impurity levels of Te, Ge, and Zn in $\text{Al}_x\text{Ga}_{1-x}\text{As}$ as a function of the concentration of AlAs in the solid solution. The results arrived at here indicate that the depth of the acceptor level in solid solutions with the formula $\text{Al}_x\text{Ga}_{1-x}\text{As}$ is 0.028 to 0.032 eV and almost does not depend on the composition of the solid solution. Figures 1; tables 2; references 5: 4 Russian, 1 Western.

FEATURES OF CURRENT TRANSPORT AND IMPURITY DISTRIBUTION IN DOPED EPITAXIAL STRUCTURES

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY, FIZIKA in Russian No 3, 1977 pp 52-56 manuscript received 20 Apr 76

YEZHOVSKIY, YU. K., SANITAROV, V. A., and KALINKIN, I. P., Leningrad Technological Institute imeni Lensovet [the Leningrad Soviet]

[Abstract] This paper gives the results of a study of the properties of epitaxial films of CdSe doped both with an isovalent impurity, zinc, and with a heterovalent impurity, gallium, for the purpose of determining similarities and differences in their influence on conductivity. Films were obtained by vacuum sputtering and condensation of the material in a closed container, using mica substrates. The dopants were added as the films grew by combined sputtering of cadmium selenide and zinc (or gallium) from two independent sources. Charge carrier mobility was determined from the Hall effect in alternating current in an alternating magnetic field. It was demonstrated that increasing the content of the dopant in the gas phase results in a considerable reduction in resistivity of the final films, but the concentration of charge carriers increases but slightly, and an increase in their mobility is the main effect. This indicates that when epitaxial films of CdSe are doped with a donor impurity the size of the intercrystallite barrier is changed and the conditions for carrier transport are improved. It is demonstrated further that in doped films intercrystallite barriers are absent and the carrier scattering mechanism approximates that detected in single crystals. It is suggested that removal of the intercrystallite energy barrier is caused by localization of part of the activator along faces between crystallites and by neutralization of acceptor states into neutral complexes. The increase in mobility is more pronounced when doping with zinc than with gallium, although the carrier concentration is lower in the first instance. This proves that the main mechanism for the increase in mobility is not tunneling of carriers through the barrier. The presence of zinc in the gas phase can result in a two-sided effect: first zinc can replace cadmium in the lattice, without forming an energy level in the forbidden band; second, it can be introduced into the interstice with formation of a Zn_i donor center. The latter results in "healing" of defects. When doping with gallium, the gallium only replaces cadmium in the lattice with formation of a singly ionized donor center. The difference between the influence of zinc and gallium consists in the fact that the first practically heals defects, improving the structure and the process of carrier transport along the film, whereas the second, reducing the barrier charge, creates complexes which take part in scattering electrons. Scattering by ionized defects is the predominant mechanism in both cases. Figures 4; tables 1; references 13: 9 Russian, 4 Western.

CONDUCTIVITY AND PARAMETERS OF IMPURITY CENTERS IN COMPENSATED SINGLE CRYSTALS OF CdTe

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY, FIZIKA in Russian No 3, 1977 pp 40-43 manuscript received 11 Jun 76

ANTONENKO, R. S., GAVRILENKO, N. V., ZHORNOVYY, I. V., KOLISNIK, M. G., and FALECHUK, A. D., Chernovtsy State University

[Abstract] It is demonstrated in this paper that isothermal annealing of raw crystals of CdTe in large amounts of Cd + LiCl salt melts at 900°C for 9-17 hours makes it possible, while maintaining the type of conductivity, to achieve greater purity with respect to impurities which can not be monitored and to increase considerably the level of compensation of these crystals. Studies were made of the conductivity and optical and galvanomagnetic properties of CdTe single crystals grown from a homogeneous melt by a modified Bridgman technique, with a controlled crystallization rate of 0.2 mm/h. Conductivity was n-type. Extraction-type isothermal annealing was used to reduce the density of elastic strains and the concentration of residual impurities. Pulling from the Cd + LiCl salt melt proved preferable over other methods because lithium atoms in the course of migrating through the crystal in the pulling process are capable of replacing electrically bound copper in the CdTe matrix, which is the most probable impurity in significant concentration, and, coalescing at defects, of forming neutral complexes. There is a significant concentration of carrier scattering centers in CdTe single crystals. The process described here also apparently alters the carrier scattering mechanism. It is concluded that pulled single crystals of CdTe are suitable with respect to sensitivity in the normal absorption region, compensation level, optical transmission, and a number of other characteristics, as a semiconductor material for developing highly sensitive photodetectors with stable parameters at room temperature and somewhat higher, electro-optical modulators for the visible range of the IR emission spectrum, light transducers, and ionizing radiation detectors with high resolution. Figures 3; references 15: 8 Russian, 7 Western.

USSR

UDC 537.226:621.319.4

BREAKDOWN OF 'HEALED' THIN Ta_2O_5 FILMS

Tomsk IZVESTIYA VUZOV, FIZIKA in Russian No 4 Apr 77 pp 120-124 manuscript received 6 Jul 76

BREKHUNOV, V. I., MOTOSHKIN, V. V., and MUKHACHEV, V. A., Tomsk Institute of Automated Control Systems and Radio Electronics

[Abstract] The breakdown of thin Ta_2O_5 films was studied in experiments which had been produced on glass substrates with aluminum electrodes by first spraying tantalum in an oxygen plasma of a low-voltage Penning discharge. Defects in the specimens were then "healed" by a special treatment, prior to deposition of the upper electrode. The electric strength was measured as a function of time, i.e., the duration of a square voltage pulse, and as a function of the ambient temperature. The results are compared here with theoretical calculations pertaining to the thermal mechanism of breakdown in dielectric films. The mechanism of electrical conduction in "healed" dielectric films is also discussed in terms of various hypotheses on this subject. Figures 2; references 19: 17 Russian, 2 Western.

USSR

UDC 53.043:537.224:537.529

RADIATION RESISTANCE OF INORGANIC GLASSES

Tomsk IZVESTIYA VUZOV, FIZIKA in Russian No 4, Apr 77 pp 58-62 manuscript received 24 Jun 76

VOROB'YEV, A. A., ZAVADOVSKAYA, YE. K., FEDOROV, B. V., and STARODUBTSEV, V. A., Tomsk Polytechnic Institute imeni S. M. Kirov

[Abstract] Both theoretical and experimental research has been done at the Tomsk Polytechnic Institute concerning energy conversion and defect accumulation in inorganic glasses, based on certain analogies with ionic crystals. The radiation resistance of such glasses is determined on the defectiveness of the structure and on the energy of the element-oxygen bond, the average level of bond forces being determined by the glass transition temperature. Defects occur in those structural components which appear most prominently, defects in filling the energy levels of MO_m^{n-} polyhedra being regarded as radiation defects. For practical applications one should select a material which has the highest glass transition temperature and is least defective. References 15: 12 Russian, 3 Western.

USSR

INDUCTION METHOD OF MEASURING DYNAMIC MAGNETOSTRICTION

Tomsk IZVESTIYA VUZOV, FIZIKA in Russian No 4, Apr 77 pp 49-53 manuscript received 26 Feb 76 revised 13 Aug 76

NEZHIZHIM, V. A., and PROKOPCHENKO, YE. A., Zaporozhe Pedagogical Institute

[Abstract] An instrument is described which measures the dynamic magnetostriction characteristic by the induction method, where the emf induced in a specimen by its deformation is proportional to the strain rate and to the magnetic induction. The dynamic magnetostriction consists of a constant component and a second-harmonic component, both the former and the amplitude of the latter being proportional to the magnetic induction squared. The instrument consists of a magnetizer for strip specimens, an inductive transducer, an rms voltmeter, an electronic integrating or differentiating circuit, and a ferrometer with an oscillograph. The method has been tested on grade M-6 transformer steel. The results of measurements were found to depend, both in magnitude and in sign, on their direction relative to the grain orientation in specimens. Figures 4; references 8: 7 Russian, 1 Czechoslovak.

USSR

THERMOMAGNETIC RECORDING OF INFORMATION BY AN ELECTRON BEAM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1561-1562 manuscript received 25 Nov 76

BALBASHOV, A. M., PLAKSIY, YU. S., TRON'KO, V. D., and CHERVONENKIS, A. YA., Kiev State University

[Abstract] The search for new memory devices has drawn the attention of researchers to magnetic epitaxial garnet films, on which information is recorded by a thermomagnetic method using an optical beam. These memories feature rapid, nonvolatile, high-density storage which can, however, be erased and transferred. The authors demonstrate for the first time the possibility of recording of information on epitaxial ferrite-garnet films by means of a scanning electron beam. Information is still read optically. Resolution is about 500 lines per millimeter. Individual domains 20 μ m in diameter and continuous lines can be recorded. References 6: 2 Russian, 4 Western.

USSR

UDC 533.99

QUASISTATIC MODEL FOR SELECTION OF COPPER EXPLODING WIRES IN CIRCUITS WITH
INDUCTIVE ENERGY STORAGE

Leningrad ZHURANL TEKHNICHESKOY FIZIKI in Russian Vol 46 No 6, Jun 77 pp 1181-
1186 manuscript received 2 Feb 76

ZOLOTAREV, E. I., POLYANSKIY, L. E., SANIN, I. V., and SILKINA, I. L.

[Abstract] A quasistatic model is used to design an exploding wire circuit in which the exploding wire is represented by apparent resistivity and specific energy. The relationships between these quantities are measured experimentally for various heating conditions. The use of the theory of similarity of circuits with exploding wires in a somewhat modernized form allows the problem of optimization of selection of cross section of the wire to be solved in its general form. Simple formulas are produced for calculation of the state of the circuit at the moment of the beginning of the rapid rise in resistance of the wire when the cross section of the wire is optimal. It is found that the change in apparent resistivity of wires after melting in circuits with various periods of oscillation is not uniquely determined by specific energy applied. The fraction of this energy expended on expansion of the metal increases with increasing heating time. References 10: 8 Russian, 2 Western.

USSR

UDC 533.9

NEUTRALIZATION OF THE CHARGE OF AN ELECTRON BEAM IN A PLASMA

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 46 No 6, Jun 77 pp 1150-
1155 manuscript received 19 Jan 76

NOSOVA, L. M., and GORBUNOV, L. M., Institute of Physics imeni P. N. Lebedev,
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[Abstract] A study is made of the equilibrium of a relativistic electron beam in a plasma in the hydrodynamic approximation, considering not only the natural magnetic field of the current, but also the charge separation field, and it is shown that estimates of the current based on the arbitrary, constant, local degree of neutralization are not confirmed. Integral charge neutralization occurs in the equilibrium state. The equilibrium current in this case depends very little on the parameters of the plasma and is near the value corresponding to complete localized neutralization of the beam charge. This means that as the radius increases the electric field falls off more rapidly than the magnetic field, and at distances great enough from the axis the beam configuration is determined by equality between thermal pressure and magnetic field pressure. Therefore equilibrium can be maintained when $E \neq 0$ without any appreciable change in the magnetic field or the beam current. References 9: 4 Russian, 5 Western.

USSR

CONSTRUCTION OF SUPERSONIC ASYMMETRICAL NOZZLES

Moscow MEKHANIKA ZHIDKOSTI I GAZA in Russian No 3, May/Jun 77 pp 87-94 manuscript received 22 Nov 76

RYLOV, A. I.

[Abstract] Problems are studied, related to the construction of optimal contours of asymmetrical flat nozzles. Based on the method of the test contour, necessary conditions for optimality of configurations are presented and a solution is constructed containing a section of a bilateral extremal, and configurations not containing this section are numerically analyzed. The influence of the intensity of the compression wave on the thrust of a "short" asymmetrical nozzle is studied. It is shown that replacement of the centered wave with a compression wave of very low intensity changes the thrust of the nozzle insignificantly. References 14: 13 Russian, 1 Western.

USSR

MIXING BELOW THE MOLECULAR LEVEL AND DEVELOPMENT OF A CHEMICAL REACTION IN A TURBULENT STREAM

Moscow MEKHANIKA ZHIDKOSTI I GAZA in Russian No 3, May/Jun 77 pp 32-41 manuscript received 11 Jun 76

KUZNETSOV, V. R.

[Abstract] Ignition in a turbulent mixing layer with variable temperature is studied, revealing a number of peculiarities. The chemical reaction occurs under nonadiabatic conditions, so that heat transfer is significant. Also, since the temperature of one of the streams mixed is high, ignition occurs near the boundary layer of mixing. In this area, pulsations in concentration are great. The influence of turbulence on the chemical reaction of combustion is studied under these conditions. It is found that the process is usually described by means of the equation for the distribution of temperature probabilities. This equation is derived and its solution analyzed. The intensity of temperature pulsations is calculated for the case of mixing with no chemical reactions without using empirical constants. An ignition criterion is produced. The development of the process of ignition in a turbulent stream depends essentially on scalar dissipation. The significance of this parameter should be great whenever chemical reactions are concentrated in narrow zones. References 20: 15 Russian, 5 Western.

SEPARATED FLOW AROUND A STEP WITH THE FORMATION OF A TURBULENT WAKE

Moscow MEKHANIKA ZHIDKOSTI I GAZA in Russian No 3, May/Jun 77 pp 17-25 manuscript received 24 Sep 76

GOGISH, L. V., and STEPANOV, G. YU.

[Abstract] A method is developed for calculation of the flat turbulent wake beyond a step, interacting with an unlimited potential flow of an incompressible fluid, considering the initial boundary layer and injection (evacuation) in the isobaric base region. Friction against the wall beyond the step is ignored. The distribution of parameters along the wake is found to be little dependent on the velocity profile presumed, and agrees almost completely when the independent change in turbulence constants is considered. However, local flow elements such as the shape of the stream lines in the vicinity of the stagnation point do depend greatly on the velocity profile. References 9: 3 Russian, 6 Western.

USSR

EXPERIMENTAL STUDY OF AN ELECTRIC DISCHARGE LASER WITH SUPERSONIC GAS FLOW IN A MAGNETIC FIELD

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 15 No 3, May/Jun 77 pp 635-642 manuscript received 4 Aug 76

IVANOV, R. S., KARPUKHIN, V. T., KOROLEV, N. M., MALIKOV, M. M., NEDOSPASOV, A. V., and STOTSKIY, G. I., Institute of High Temperatures, Academy of Science USSR

[Abstract] The working mixture ($\text{He}+\text{CO}_2+\text{Xe}$) used in an electric discharge laser with supersonic gas flow perpendicular to crossed electric magnetic fields contains no nitrogen, comparatively little carbon dioxide, plus an easily ionized additive (xenon). Data are produced on the variation in laser radiation intensity with magnetic field intensity. The effective Hall parameter, electric fields, electron temperature and electron concentration in the plasma are measured. The helium, carbon dioxide and xenon mixture was pumped from the mixing tank through the channel-optical resonator for 0.5-1 s; magnetic field duration was 45-50 ms, with the electric discharge provided by a capacitor bank through ballast resistors. References 15: 7 Russian, 8 Western.

USSR

STUDY OF A COPPER VAPOR PULSE LASER AT HIGH POWER LEVELS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1413-1417 manuscript received 2 Aug 76

ISAYEV, A. A., and LEMMERMAN, G. YU., Physics Institute imeni P. N. Lebedev Academy of Sciences USSR Moscow

[Abstract] This work studies a pulse laser operating on copper vapor with high supply power. In order to increase the supply power, the authors used three type TG11-1000/25 switching thyratrons, operating in parallel. The anode of each thyatron was connected to its own operating capacitor; all capacitors were charged by a single power supply. Decoupling inductors were connected between the anodes of the thyratrons. The grids of all thyratrons were powered by a single high-power ignition pulse generator. This power supply system operated stably at frequencies of 6-20 KHz with a mean power of up to 5 kW. Stimulated emission was studied in two discharge tubes of corundum with inside diameters of 20 and 28 mm and lengths of the heated portion of 700 and 800 mm respectively. The resonator consisted of one opaque aluminum mirror with a radius of curvature of 3 m and a plane-parallel quartz plate with 8% reflection. The resonator was 1.2 m in length. Increasing the diameter of the discharge tube caused an increase in power and efficiency of the laser with similar excitation conditions. References 6 (Russian).

USSR

UDC 621.378.325

STUDY OF THE OUTPUT CHARACTERISTICS OF A ROTATING GAS RING LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1418-1425 manuscript received 3 Aug 76

PRIVALOV, V. YE., and FILATOV, YU. V., All-Union Scientific Research Institute for Metrology, Leningrad

[Abstract] A study is made of the general expression for the output characteristic of a rotating gas ring laser. Results are presented from an experimental study of the splitting of natural frequencies of the rotating ring-cavity when a homogeneous dielectric medium is present in it. It is shown that splitting of natural frequencies is inversely proportional to the index of refraction of the medium in the resonator. A study is made of the possibility of decreasing the coupling of oppositely directed waves by back scattering. It is experimentally demonstrated that the compensation method, achieved by means of return mirrors, significantly decreases the coupling of oppositely directed waves. The experimental study was performed using an He-Ne laser with $\lambda = 0.63 \mu\text{m}$. The perimeter of the triangular resonator was 0.85 m. The active element was a two-anode gas-discharge tube filled with ^3He and ^{20}Ne in a ratio of 7:1. The total gas pressure was 1.6 mm Hg. Measurements were performed at a speed of rotation corresponding to a difference frequency of 500 KHz. References 20: 14 Russian, 6 Western.

USSR

UDC 621.378.33

CONTRAST POWER RESONANCES IN A He-Ne/ $^{127}\text{I}_2$ LASER WITH GREAT EFFECTIVE ABSORPTION LENGTH

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1433-1440 manuscript received 8 Sep 76

MOGIL'NITSKIY, V. S., KOLOMNIKOV, YU. D., Siberian State Scientific Research Institute for Metrology, Novosibirsk

[Abstract] A study is made of a He-Ne/ $^{127}\text{I}_2$ laser with a long internal absorption cell, in order to determine the optimal conditions for production of contrast power resonances. An optical delay line was used as the internal absorption cell in order to increase the effective absorption length. The hyperfine absorption spectrum of the iodine observed in this laser is described. The use of the delay line allows the transition to be made from a laser with heterogeneous gain to a laser with homogeneous gain. The area of frequency retuning of stimulated emission in a laser with homogeneous gain is equal to the intermode spacing of the empty resonator. This limits the number of resonances observed. The low absorbent pressure used allows more precise information to be produced on the collision processes in the molecular gas. The narrow

contrast resonances achieved allow precise coupling of the emission frequency to the center of the line of absorption of the hyperfine iodine component. References 27: 14 Russian, 13 Western.

USSR

UDC 621.378.4

MULTISTAGE TRANSFORMATION OF THE EMISSION ENERGY OF PUMPING TO LOW-FREQUENCY EMISSION ENERGY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1447-1455 manuscript received 18 Aug 76

BABIN, A. A., FREYDMAN, G. I., and SHCHELOKOV, A. N., Scientific Research Institute for Radio Physics, Gor'kiy

[Abstract] A discussion is presented of the possibility of increasing the conversion factor of pumping energy to long-wave radiation by the use of a multistage process in a single nonlinear element. The plane-wave approximation is used to study the characteristics of multistage conversion in a laser with low frequency radiation feedback. The conversion factor is calculated as a function of the number of stages of conversion and the ratio between pumping power density and self-excitation threshold. Both the e-eo interaction in proustite and the e-ee interaction in LiIO_3 meet the phase locking conditions for the multistage process. References 17: 5 Russian, 12 Western.

USSR

UDC 378.335 + 530.145

REACTION OF THE GAS DISCHARGE CURRENT TO VARIATION IN OPTICAL POWER AS THE BASIS FOR REGULATING THE EMISSION LEVEL OF A LASER

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY, FIZIKA in Russian No 3, 1977 pp 20-24 manuscript received 5 Apr 76, after correction 7 Oct 76

BORZUNOV, N. G., POPOV, L. N., and POYZNER, B. N., Siberian Physics and Technical Institute imeni V. D. Kuznetsov at Tomsk State University

[Abstract] This article suggests using the reaction of the gas discharge current to variation in the emission level of a laser as a feedback circuit in systems for automatically monitoring the output of a laser, especially in lasers whose high emission level or wavelength ranges render the use of optical elements difficult. A number of experiments were conducted to gain a deeper understanding of the kinetics of processes in discharge of a He-Ne laser, which distinguished by simultaneous emission on three quantum jumps with different

wavelengths. A study is made in particular of the relationship between the discharge current of a He-Ne laser and the presence of stimulated emission at $\lambda = 3.39 \mu\text{m}$, whose role has not been analyzed in previous studies. It is demonstrated that the presence or absence of emission at wavelength $3.39 \mu\text{m}$ is reflected in curves expressing the relationship between difference in discharge current in the presence and absence of generation and emission intensity. This fact is used to design circuits to read out infrared radiation accompanying generation of visible light by a gas laser. A selective filter is placed in the cavity to eliminate generation of rays of all wavelengths other than infrared. The laser's reflector is covered by the shutter and a measurement is made of the change in the d.c. component of the gas discharge current brought about by closing the shutter. A reading other than zero indicates the presence of infrared rays of this wavelength. Calibration curves are used to estimate the level of infrared radiation accompanying generation of visible light in different operating modes. The experiments described here demonstrate in particular that the intensity of electron excitation and the presence of generation at the $3s_2-3p_4$ jump influence the nature of the change in the contribution of neon to ionization. A block diagram is given for a system for automatically regulating the emission output of lasers of this sort and variants of this system are discussed. Figures 3; references 9: 6 Russian, 3 Western.

USSR

UDC 533.6.011+536.37

LIGHT AMPLIFICATION IN RECOMBINING GAS DYNAMIC STREAMS

Moscow MEKHANIKA ZHIDKOSTI I GAZA in Russian No 3, May/Jun 77 pp 160-162 manuscript received 23 Nov 76

KOCHELAP, V. A., and KUKIBINYI, YU. A.

[Abstract] It is suggested that recombining sulphur atoms to be used for the creation of powerful chemical lasers be obtained from gaseous sulphur-containing compounds such as SO_2 , H_2S , CS_2 , and OCS , and the corresponding value of α (light gain factor) is calculated for gas dynamic pumping as well as for the processes $\text{XO} + \text{O} (+\text{M}) \rightarrow \text{XO}_2 (+\text{M}) + \omega$, $\text{X} = \text{N}, \text{S}$. In determining the wave length of transitions, gain and criterion for population inversion as a function of temperature T and partial pressures of the reagents, experimental data were used on the spontaneous chemiluminescence of the processes discussed. The profiles of composition and temperature in the nozzle were calculated according to the one-dimensional theory in the approximation of sudden freezing in the critical cross section of the nozzle: the composition upstream of this section is assumed locally in equilibrium, the composition downstream is assumed constant. The calculations indicate that the reaction of recombination of sulphur atoms is interesting, and that in the case of CS_2 and OCS , a further increase in gain can be achieved by introducing an inert filler and improving γ . Thermal pumping with subsequent adiabatic cooling in a supersonic nozzle can achieve significant gain, on the order of 10^{-2} - 10^{-3}cm^{-1} . References 11 (Russian).

USSR

UDC 621.378.325

STUDY OF THE PROPERTIES OF AN UNSTABLE RESONATOR WITH A DIHEDRAL CORNER REFLECTOR IN A CW FLOW-THROUGH CO₂ LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1456-1460 manuscript received 26 Aug 76

ANAN'YEV, YU. A., KUPRENYUK, V. I., SERGEYEV, V. V., and SHERSTOBITOV, V. YE.

[Abstract] An experimental study is presented of the increase in amplitude field uniformity in an unstable flow-through gas laser when one of the mirrors of the resonator is replaced by a dihedral corner reflector, an analog of a total-internal-reflection prism. Studies were performed using a CW electric-discharge CO₂ laser with a transverse flow of gas mixture through the zone of the resonator. The resonator was placed in the lower portion of the flow, in an area of exponential decrease in the gain factor. It is shown that the use of the dihedral reflector can greatly increase the uniformity of distribution of radiation over the cross section of the resonator. References 7: 6 Russian, 1 Western.

USSR

UDC 621.373.826.038.823

MODEL OF THE MEDIUM FOR DESIGN OF THE RESONATORS OF GAS DYNAMIC CO₂ LASERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1461-1466 manuscript received 25 Aug 76

ALEKSANDROV, B. S., ANAN'YEV, YU. A., LAVROV, A. V., and TRUSOV, V. P.

[Abstract] A study is made of the results of a cycle of resonator design calculations performed within the framework of a detailed "nozzle" model. The possibility is studied of applying a mathematical model of the medium including only two equations to design calculations of gas dynamic laser resonators. It is shown that within the range of parameters studied for the medium, this model yields satisfactory calculation accuracy. Limitations of the application of the model may result first of all from the need to consider the population of the lower laser level. As concerns still simpler models of the medium, they should probably not be used, since they may lead to significant calculation errors. References 22: 12 Russian, 10 Western.

USSR

UDC 621.378.33:535.853

FREQUENCY CONVERSION OF A CW CHEMICAL HF LASER IN NONLINEAR CRYSTALS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1467-1472 manuscript received 25 Jul 76

KLEMENT'YEV, V. M., KOLPAKOV, YU. G., and PECHERSKIY, YU. YA., Institute of Semiconductor Physics, Siberian Affiliate, Academy of Sciences USSR, Novosibirsk

[Abstract] A description is presented of a CW chemical HF laser manufactured by the authors. Results are presented from studies of the frequency mixing of its radiation to the visible range by means of a CW He-Ne laser with $\lambda = 0.63 \mu\text{m}$. Results are presented from studies of the effectiveness of transformation of the radiation of the HF laser to the second harmonic and combination frequencies in crystals of LiNbO_3 , LiIO_3 , and Ag_3AsS_3 . The most effective transformation (in proustite) achieves a second harmonic power of about $3 \mu\text{W}$ with a basic radiation power of about 100 mW . Twenty-one radiation lines are produced in the $1.39\text{--}1.49 \mu\text{m}$ range. Improvement of the design of the laser and optimization of the processes of transformation of its radiation will probably produce basic radiated powers at the 10 W level with transformed frequency power outputs of tens of mW . References 10: 4 Russian, 6 Western.

USSR

UDC 621.373.826.038.823

GAIN OF A WAVEGUIDE CO_2 LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1482-1487 manuscript received 28 Aug 76

GRIGOR'YANTS, V. V., KUZYAKOV, B. A., and SINITSY, A. M., Institute of Radio Electronics, Academy of Sciences USSR, Moscow

[Abstract] A study is made of the unsaturated gain of the active medium of a waveguide CO_2 laser or amplifier and its variation with the primary operating parameters--pressure and composition of the operating mixture, electron density in the discharge, etc. An analytic expression is produced for the gain of the CO_2 laser. The variation in gain is studied as a function of gas pressure and laser tube diameter for various values of pumping current. The significance of various mechanisms of relaxation of excited molecules in the plasma of a waveguide CO_2 laser is discussed. The results explain the experimentally observed behavior of the gain of a CO_2 laser with varying pressure. For tubes of identical diameter (1 mm) the theoretical and experimental curves are identical and maximum gain is achieved at $P \approx 70 \text{ mm Hg}$. References 22: 7 Russian, 15 Western.

USSR

UDC 621.373.029.7.001.5

CALCULATION OF THE HEATING OF MATERIALS BY LASER RADIATION CONSIDERING THE
TEMPERATURE DEPENDENCE OF THERMOPHYSICAL COEFFICIENTS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1509-1516 manu-
script received 2 Sep 76

RYKALIN, N. N., UGLOV, A. A., and NIZAMETDINOV, M. M., Institute of Metallurgy
imeni A. A. Baykov, Academy of Sciences USSR, Moscow

[Abstract] The problem of calculation of the heating of materials by concentrated laser radiation or an electron beam with gaussian distribution of intensity is of scientific and practical interest for a number of applications. This article studies a very general case; the temperature dependences not only of the heat conductivity coefficient, but also of the volumetric specific heat are considered. The problem is studied in its axisymmetrical, three-dimensional statement, for heating of metals by a surface heat source with the gaussian distribution. Assuming that the thermophysical coefficients vary linearly with temperature, an approximate algorithm is produced for the task of calculating the temperature field, allowing quantitative estimates to be produced without the use of numerical methods. Information is presented on heating rates and surface temperature rise rate for a number of metals. References 15: 12 Russian, 3 Western.

USSR

UDC 621.378.325

ANALYSIS OF REACTION OF LASER RESONATOR RING SYSTEMS TO MISALIGNMENT

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1517-1521 manu-
script received 21 Sep 76

AL'TSHULER, G. B., ISYANOVA, YE. D., KARASEV, V. B., LEVIT, A. L., OVCHINNIKOV,
V. M., and SHARLAY, S. F.

[Abstract] A new type of optical ring resonator is suggested in which a self-conjugate beam exists, regardless of placement of the mirrors. The drift of the self-conjugate beam is estimated in case the mirrors are misaligned. The problem arises because in solid-state lasers, even with high accuracy of adjustment of reflecting surfaces, heterogeneity of the active and other elements of the laser, as well as the optical wedge present in them, acts like misalignment of the mirrors. In resonators with an even number of mirrors not in the same plane, regardless of the position of the mirrors, there is a self-conjugate beam. Misalignment of the resonator due to external influences causes drift of the closed trajectory which depends greatly on the placement of the mirrors. Mirrors in which $\Gamma = 180^\circ$ have the least sensitivity to misalignment. This peculiarity of ring resonators with an even number of mirrors allows them to be used to produce a resonator which cannot be misaligned without the need to attach the mirrors to a special single rigid base. These resonators are less sensitive to laser element aberrations. References 5 (Russian).

USSR

UDC 621.378.385

STUDY OF THE AMPLIFICATION OF SUBMILLIMETER WAVES IN MOLECULAR GAS MEDIA WITH OPTICAL PUMPING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1522-1528 manuscript received 30 Jul 76

DYUBKO, S. F., FESENKO, L. D., and BASKAKOV, O. I., Khar'kov State University

[Abstract] A study is presented of the gain in molecular gas media with optical pumping by the radiation of a CO₂ laser. These studies are important both for an understanding of the processes occurring in submillimeter lasers with optical pumping and for the design of lasers which are optimal in the sense of output power. Gain factors are measured for certain radiation lines in continuous submillimeter lasers based on the molecules HCOOH, CH₃OH, C₂H₂F₂, CH₃I and CD₃I as functions of the pumping intensity, pressure and polarization of the input signal. It is noted that the degree of polarization anisotropy of the excited medium depends on the type of pumping transition. The maximum gain of 3.15 dB/m is obtained on transition of the HCOOH molecule with $\lambda = 432.6 \mu\text{m}$. References 10: 3 Russian, 7 Western.

USSR

UDC 539.216.22:669

EXPERIMENTAL STUDY OF LASER DESTRUCTION OF THIN METAL FILMS BY THE QUARTZ RESONATOR METHOD

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1529-1536 manuscript received 6 Dec 76

METEV, S. M., VEYKO, V. P., STAMENOV, K. V., and KALEV, KH. A., Sofia State University, Bulgaria

[Abstract] Some of the conclusions based on a two-phase model of laser destruction of thin absorbing films are experimentally tested. A new method of investigation is used, allowing precise quantitative measurements of changes in film mass under the influence of laser radiation. The thresholds Q_1 and Q_2 of initial and total destruction of the film are measured by means of an experimental dependence of the thickness of the evaporated layer H on light flux density Q . The theoretically predicted functions $Q_{1,2}(H)$, $Q_{1,2}(\tau)$, $Q_{1,2}(A)$, which had been theoretically predicted, are experimentally produced for the first time (H is the film thickness, τ is the laser pulse length, A is the reflectivity of the film). The experiments confirmed the conclusion of the two-phase model that when the zone of action is large, the process of destruction is described quite well by an evaporation model. The integral characteristics of the model can be successfully studied by the method of the quartz resonator. The quartz resonator method in general is quite precise and

convenient for the study of processes of mass transfer upon interaction of short laser radiation pulses with thin films. References 10: 8 Russian, 2 Western.

USSR

UDC 621.378.9:533.9.02

ACCELERATION OF CARBON NUCLEI PRODUCED IN A LASER INJECTOR ON THE SYNCHRO-
PAASOTRON OF THE JOINT INSTITUTE FOR NUCLEAR RESEARCH

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1547-1549 manu-
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ANAN'IN, O. B., BALDIN, A. M., BEZNOGIKH, YU. D., BYKOVSKIY, YU. A., GOVOROV, A. I., ZINOV'YEV, L. P., KOZYREV, YU. P., MAKAROV, L. G., MONCHINSKIY, V. A., NOVIKOV, I. K., PEKLENKOV, V. D., RASPOPIN, A. M., and SEMENYSHKIN, I. N., Moscow Institute of Engineering and Physics; Joint Institute for Nuclear Research, Dubna

[Abstract] Methodological improvements made to the JINR synchrophasotron have made this accelerator the world's first relativistic nucleus (deuterons and α particles) accelerator. The results of studies have shown that a laser plasma is an effective source of multiple-charged ions (MCI) the emission characteristics of the MCI being quite favorable for injection of the ions into accelerator systems. In the present experiment, a solid-state laser was used providing a radiation flux density of about $5 \cdot 10^{13}$ W/cm² on targets of carbon and deuterated polyethylene. The number of deuterons and carbon nuclei per laser pulse was measured at several points in the accelerator system. The beam of carbon nuclei was accelerated and bombarded a layer of nuclear photographic emulsions, which recorded the tracks of the decay of the nuclei in the emulsion (silver) upon collision with the carbon nuclei. The intensity of the beam of carbon nuclei reached 10^5 particles per pulse. References 12: 11 Russian, 1 Western.

USSR

UDC 621.378.32

CONTINUOUS DYNAMIC TUNING OF PULSE LASER RADIATION FREQUENCY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1550-1552 manuscript received 10 Sep 76

MAKOGOV, M. M., SERDYUKOV, V. I., and SOLODOV, A. M., Institute of Atmospheric Optics, Siberian Affiliate, Academy of Sciences USSR, Tomsk

[Abstract] It is demonstrated that in lasers with broad gain lines (for example, solid-state lasers), it is possible to achieve emission with broad-band continuous variation of the radiation frequency in a range two or more orders of magnitude greater than the interval between modes, if the length of the resonator of the laser is varied during emission by 100 or more wave lengths. Placement of a rotating plane-parallel transparent plate in a static resonator can be used to achieve this dynamic resonator effect. References 16: 14 Russian, 2 Western.

USSR

UDC 621.373.826.038.823

THE OPERATION OF AN AEROSOL COUPLER AT HIGH RADIATION INTENSITY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1559-1560 manuscript received 20 Nov 76

BENDITSKIY, A. A., BOGATIKOV, A. A., KRAVTSOV, V. YE., RUKMAN, G. I., SHELEMIN, YE. B., and KHROMOV, A. V., All-Union Scientific Research Institute for Optical and Physical Measurements, Moscow

[Abstract] A study is made of the behavior of NaCl particles acted upon by the radiation of a CO₂ laser with significantly lower intensity than in earlier experiments (around 3-20 kW/cm²). It is found that when NaCl particles pass through areas with intensities of over 5 kW/cm², flashes of white light occur which are bright enough to be seen in daylight. This phenomenon can significantly influence the operation of an aerosol coupler. The spectrum of the glow is presented for a laser radiation intensity of 20 kW/cm². References 4: 3 Russian, 1 Western.

USSR

UDC 621.373.826.038.823

THEORETICAL STUDY OF THE POSSIBILITY OF GENERATION OF SHORT, POWERFUL PULSES
USING AN ELECTRIC IONIZATION CO LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1571-1572 manu-
script received 15 Dec 76

DOLININA, V. I., SUCHKOV, A. F., and URIN, B. M., Institute of Physics imeni
P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] A study is presented of the possibility of generation of short-
powerful radiation pulses in an electric ionization CO laser both with Q
switching and in the free emission mode. Specific energy characteristics of
the pulses generated are defined (efficiency, power, energy) and pulse shape
is determined. The active medium of the CO laser is a multilevel medium, the
distribution of CO molecules among vibrational levels with respect to time
being unsteady even after the pumping power is switched off. It is shown
that it is possible in principle to produce radiation pulses 20 ns in length
with an efficiency of about 10%.

USSR

UDC 621.373.826.038.823

TIME BEHAVIOR OF ELECTRON CONCENTRATION IN A COPPER VAPOR LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1572-1575 manu-
script received 17 Dec 76

BATENIN, V. M., BARMAKIN, V. A., VOKHMIN, P. A., YEVTYUNIN, A. I., KLIMOVSKIY,
I. I., LESNOY, M. A., and SELEZNIVA, L. A., Institute of High Temperatures,
Academy of Sciences USSR, Moscow

[Abstract] Results are presented from measurements of the time behavior of
the concentration of electrons n_e in a copper vapor laser. The time behavior
of the concentration of electrons during and between pumping pulses was de-
termined by different methods. Between pulses, n_e was measured by a dual-beam
interferometer, assuming that the plasma was isothermal. During current pulses,
 n_e was estimated on the basis of measured impedance of the discharge gap. Ref-
erences 6: 4 Russian, 2 Western.

USSR

UDC 621.327.8

RELAXATION PROCESSES IN THE DISCHARGE OF A COPPER HALIDE LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1575-1577 manuscript received 18 Dec 76

OLEYNIK, YU. M., and ROGOZHIN, A. V.

[Abstract] A study of the qualitative and relative quantitative spectral composition of discharge and time behavior of the intensities of various transitions can be used to determine the relative significance of relaxation processes in a discharge. With this purpose in mind, a spectrographic study was made of the radiation along a discharge tube without a resonator in the 200.0-600.0 nm range. For a CuBr discharge (capacitance $C \approx 400$ pF, voltage ≈ 14 kV) with a neon pressure of about 14 mm Hg and a helium pressure of about 8 mm Hg, the current was about 60 A, pulse length about 90 ns. At a helium pressure of 14 mm Hg, with a current of 30 A, pulse length was about 180 ns. Characteristics for a CuI discharge are also presented. Long afterglow was found for some transitions in CuI. It is theorized that discharge contraction results from increased dissociative recombination processes with cooled electrons deactivating metastable states of CuI. References 6: 5 Russian, 1 Western.

USSR

UDC 535.34.666.266.52

OPTIMIZATION OF THE PROCESS OF HOLOGRAPHIC RECORDING OF INFORMATION IN PHOTOCHROMIC GLASSES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1587-1589 manuscript received 27 Dec 76

BEREZIN, P. D., KOMPANETS, I. N., TIMYSHEV, A. G., TUNIMANOVA, I. V., and TSEKHOMSKIY, V. A., Institute of Physics imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] The task was undertaken of optimizing the conditions of recording and of the parameters of holograms and thickness of photochromic glass plates (exposure, diffraction effectiveness) in order to use photochromic glass in actual semipermanent stores. Sodium-aluminum-borate glass was used with cadmium oxide doping. This glass is resistant to thermal decoloration. Results of the change in transmissivity of specimens of glass of various thicknesses as a function of temperature were used to calculate the distribution of absorption factor k through the depth of the specimen. The hologram diffraction efficiency which can be achieved for recording with a helium-cadmium laser is calculated and compared with experimental data, showing good agreement. Maximum diffraction efficiency achieved experimentally is 2.15%. A thickness of 1.5-2 mm is found to be optimal, yielding the maximum diffraction efficiency while retaining good sensitivity. References 5: 4 Russian, 1 Western.

USSR

UDC 621.373.826.038.823+546.02

SEPARATION OF ISOTOPES OF OSMIUM BY THE METHOD OF DISSOCIATION OF THE OsO_4 MOLECULE IN A TWO-FREQUENCY IR LASER FIELD

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1590-1591 manuscript received 30 Dec 76

AMBARTSUMYAN, R. V., GOROKHOV, YU. A., MAKAROV, G. N., PURETSKIY, A. A., and FURZIKOV, N. P., Institute of Spectroscopy, Academy of Sciences USSR, Moscow

[Abstract] The method of selective dissociation of molecules in a two-frequency IR laser field is used to increase the selectivity of the process of dissociation of OsO_4 molecules of the natural isotope composition. The experiments show that the maximum enrichment occurs when the frequency of radiation of the laser is tuned to the line P (6). Tuning of the laser frequency to the P(20) line produces reverse enrichment, i.e., enrichment of the mixture with the lighter isotopes. The selectivity of the process of dissociation can be increased by selecting suitable conditions for dissociation of OsO_4 molecules, for example, monoisotopic excitation of molecules. However, this would require an increase in pulse repetition frequency in order to decrease secondary, non-selective processes. References 5: 4 Russian, 1 Western.

USSR

UDC 621.373.826.038.823

A HIGH-POWER VACUUM UV HYDROGEN LASER WITH HIGH PULSE REPETITION FREQUENCY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 4 No 7, Jul 77 pp 1606-1608 manuscript received 19 Jan 77

LOZOVSKIY, P. M., CHERNOV, S. P., and ESSEL'BAKH, P. B., Moscow State University

[Abstract] A plan for a high-power vacuum ultraviolet hydrogen laser is suggested in which the cuvette containing the hydrogen is connected into the discharge of the grounded electrode of the strip line. This means that the electrodes of the laser and all measurement apparatus are at ground potential, so that breakdown at the output flanges of the laser and connected apparatus does not occur. Using this system, a laser is produced with a high pulse repetition rate (up to 400 Hz) high power (10 mW) and power stability (10%). The laser has two optical outputs. The peak power at the 161 nm wave length at one output is 20 kW, of the other--50 kW, with pulse energies of 10 and 25 uJ and pulse lengths not over 0.5 ns. In addition to the 161 nm emission line, a line in the IR range at 886 nm is also emitted. Using the same design, emission has also been stimulated in technical nitrogen at a wave length of 337.1 nm, pulse energy 125 uJ, peak power 250 kW. References 4: 2 Russian, 2 Western.

USSR

UDC 533.6.011.95:538.4

REGULAR REFLECTION OF A MAGNETOHYDRODYNAMIC SHOCK WAVE FROM A CONDUCTING WALL

Moscow MEKHANIKA ZHIDKOSTI I GAZA in Russian No 3, May/Jun 77 pp 103-109 manuscript received 9 Dec 76

PUSHKAR', YE. A.

[Abstract] A study is made of the problem of regular reflection of a magnetohydrodynamic shock wave from an infinite conducting flat wall. The flow studied is considered plane-polarized, i.e., the magnetic field and flow velocity lie in one plane, the electric field and current being perpendicular to this plane. It is assumed that the magnetic field perpendicular to the wall is not equal to zero. The solution is constructed for incident waves of various types (fast and slow). It is found that, depending on the initial data, the solution may differ qualitatively. In contrast to gas dynamics, the incident wave is reflected in the form of two waves, which may be centered waves of rarefaction. The incident slow magnetohydrodynamic shock wave decomposes upon reflection into a fast shock wave and a trailing slow shock wave if the intensity of the incident shock wave is sufficiently great. References 14: 7 Russian, 7 Western.

USSR

UDC 538.4:538.114:536.25

CONVECTION IN A VERTICAL LAYER OF MAGNETIC FLUID IN THE MAGNETIC FIELD OF A CURRENT-CARRYING PLATE

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 28-34 manuscript received 20 May 76

NOGOTOV, YE. F., and POLEVIKOV, V. K.

[Abstract] This paper is devoted to studying the effect of an inhomogeneous magnetic field on an isothermal magnetic fluid from the viewpoint of temperature distribution, local heat flows, heat transfer, and rate and pattern of convective motion. Considered here is the case when the magnetic field is created by passing current through a thin conducting plate which serves as one of the boundaries of a vertical layer of ferrofluid. It is assumed that the current is distributed evenly across the width of the plate. The problem is formulated as a two-dimensional problem of free convection of a magnetic fluid in a finite vertical layer of height λ and width d . An infinitely long thin conducting plate through which current flows serves as one of the side walls. The system of ferrohydrodynamics equations of Rosenzweig-Neuringer is used as the mathematical model. Two types of boundary conditions are considered for the upper and lower boundaries: 1) the horizontal walls are ideally heat conducting and the temperature in them varies linearly; and 2) the horizontal walls are heat insulated. Calculation results demonstrate that in the situation dealt with here thermoconvective processes in a vertical layer of magnetic

fluid are determined by gravitational and magnetic mechanisms of convection. There is no distinct relationship to the Prandtl number. The linear dimensions of the layer and, more precisely, the ratio of λ/d , show a substantial influence on the structure of convection and distribution of the temperature field. This is especially clear when the magnetic mechanism of convection predominates over the gravitational. Isolines of the magnetic field created by the plate show that the field gradient is a complex function of the three-dimensional coordinates and is always directed toward the plate. But in narrow layers of magnetic fluid gradients directed toward the ends of the plate predominate, and in wide layers, center-directed gradients predominate. Such a field distribution is conducive to formation of two superimposed convective cells in the layer. In narrow layers the fluid circulates clockwise in the top cell and counterclockwise in the bottom; with wide layers the case is just the opposite. Variations in convection patterns when varying parameter λ/d are discussed. Under ordinary conditions when both convection mechanisms are operating convective heat transfer depends on both the magnetic and gravitational mechanism. When the magnetic is less than 0.2 times the gravitational the influence of the magnetic field on heat transfer is practically unnoticeable, whereas when it is greater than 10^2 times the gravitational the magnetic mechanism dominates and the gravitational can be disregarded. The influence of convection on heat transfer becomes substantial only when the values of the magnetic and gravitational mechanisms added together are approximately equal to or greater than $2 \cdot 10^3$, i.e., when $Ra_m + Ra_g \gtrsim 2 \cdot 10^3$. Figures 5; references 7: 5 Russian, 2 Western.

USSR

UDC 532.135:538.4

MAGNETOHYDRODYNAMIC PROPERTIES OF FERROSUSPENSIONS

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 35-38 manuscript received 11 Mar 76

DEMCHUK, S. A., KORDONSKIY, V. I., and SHUL'MAN, Z. P.

[Abstract] This paper gives the results of an experimental study of the influence of an external magnetic field of specific strength on the rheological characteristics of ferrosuspensions, particularly of those containing carbonyl iron, electrolytic nickel, and Mond process nickel as the dispersed ferromagnetic. It is demonstrated that a magnetic field has a substantial influence on the mechanical behavior of ferrosuspensions, particularly on their effective viscosity. It is demonstrated that by using the characteristic Newtonian viscosity as a normalizing parameter it is possible to plot experimental flow curves in normalized coordinates and obtain a universal curve which is invariant with respect to the strength and orientation of the magnetic field and the nature of the suspension. This invariant relationship makes it possible to make approximate calculations of the effective viscosity of magnetohydrodynamic suspensions over a wide range of magnetic field intensity and rates of shear. Good agreement is obtained between experimental flow curves and results calculated by the formula suggested. The hypothesis is expressed that

the nature of the influence of the rate of straining on dipole-dipole interaction between particles of a ferromagnetic and disruption of the three-dimensional structure formed by the external field are identical in quality, and it is this fact that makes it possible to derive a universal magnetorheological characteristic for ferrosuspensions. The relaxation properties of suspensions are determined by their characteristic Newtonian viscosity, which in this case expresses the effect of an external field on the mechanical behavior of a magnetorheological composition. Some function of the energy of interaction between particles of the ferromagnetic is involved here. The universal relationship found here can be very useful for making approximate calculations of the effective viscosity of ferrosuspensions with wide variation in temperature, rates of shear, and magnetic field strength if the characteristic Newtonian viscosity is known. Figures 4; table 1; references 5 (Russian).

USSR

UDC 538.4

CALCULATION OF A THREE-DIMENSIONAL MODEL OF AN MHD CONDUCTION MACHINE WITH FRAME-TYPE ELECTRODES

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 113-118 manuscript received 19 Nov 76

GEL'FGAT, YU. M., and GORBUNOV, L. A.

[Abstract] Calculation of MHD conduction pumps with sectional frame-type electrodes is considerably complicated because the problem is a three-dimensional one in this case, owing to the fact that the frame-type electrodes contact the liquid metal along their entire inside surface. Most available information on pumps of this sort is derived from results obtained in solving two-dimensional problems. This paper is devoted to a technique for calculating a conduction pump with oblique sectional electrodes of the frame type, making it possible to take into account the three-dimensional nature of the distribution of electric currents in the channel. The problem is solved in a series of steps. Based on the design concepts chosen for the geometry of the channel and electrodes, a determination is first made of the distribution of potentials in the pump channel and in the area of conducting inserts. This results in determination of four dimensionless parameters. Then a series of formulas are applied to determine all the necessary electrodynamic parameters of the unit, including operating pressure, liquid metal flowrate, voltage drop in the channel, and electrical efficiency. Of the four dimensionless parameters, factor k_1 determines the pressure created by one frame-type electrode under static conditions; k_2 characterizes the loss of pressure in the pump's channel formed as the result of currents induced in the liquid; k_3 expresses the dimensionless resistance of a section of the channel equal to a single cycle; and k_4 corresponds to the dimensionless difference in potentials in a section of the channel whose length equals one cycle, because both a transverse and longitudinal electric field are created when liquid metal moves in a homogeneous magnetic field in the channel of a unit with frame-type electrodes. A determination is made of ranges of variation of specific parameters

within which it is possible to achieve sufficient accuracy by using 1) an approximation of ideal sectioning, 2) a solution to the two-dimensional problem, and 3) a solution to the three-dimensional problem. Maximum efficiency of the pump is achieved when the frame-type electrodes are sloping at small angles. The resistance of the electrodes has a great influence on the characteristics of this type of pump. The distribution of potentials in the electrodes was determined as a function of their geometry, i.e., of their slope angle. The resistance of the electrodes starts to increase substantially when this angle is less than 30° . It is concluded that the technique described here is suitable for solving the three-dimensional problem and that the data obtained for the geometry of the channel make it possible to determine the dimensions of its flow system which will ensure maximum thrust and electromagnetic efficiency. Figures 8; references 4 (Russian).

USSR

UDC 621.313.29:538.4

EXPERIMENTAL STUDY OF A D.C. PUMP WITH INCREASED POTENTIAL

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 105-112 manuscript received 4 Aug 76

GOLODNYAK, V. A., ZANDART, YA. YA., KLIMENKO, A. I., LIYEPIN'SH, I. A., and TOLMACH, I. M.

[Abstract] This paper gives the results of an experimental study of a d.c. pump with increased potential similar to one described in an earlier paper but operating under intensified conditions and thus requiring a number of design changes, particularly with regard to three-dimensional effects created in the channel and to the shell and the short-circuiting jumpers welded to it. In pumps of this type the length of the channel is much greater than the width of the liquid metal flowing through. The design calculations used to implement the new changes are detailed. The purpose of this paper is to compare the theoretical results obtained with experimental results arrived at from constructing and testing a model of the new pump, particularly with regard to characteristics reflecting the relationship between the potential and delivery volume of liquid metal and the relationship between the latter and the pressure gradient, as well as to test the validity of the design of various structural components and parameters, in particular, the resistance of the jumper and the resistance per unit length of the channel. The model of the pump consisted of a straight stainless steel tube of rectangular cross section with copper jumpers welded to it. A watercooled bus was placed above the channel to compensate for the reaction of the lengthwise current and both were placed in the gap of a C-shaped magnetic system. Sodium was pumped through. Measurements were made of feed, pressure at the pump's inlet and outlet, distribution of potential and temperature along the channel, voltage drop in the jumper, power supply current, current in the shunting branches of the circuit, and the magnet's excitation current. A massive amount of data was obtained; 167 operating modes were recorded, using different values of supply current and induction

in the gap. There was no more than a 15-percent margin of error between calculated and experimental results. The design of the jumper proved to be correct. A calculation is made of the actual amount of induction in the channel. It is concluded from this calculation that the currents in the channel have no noticeable demagnetizing effect. Further study has to be made with regard to taking into account losses in the triangular end sections of the channel and making a more reliable calculation of hydraulic losses. It is concluded that the calculation formulas presented can be used for engineering calculations. Figures 5; table 1; references 5 (Russian).

USSR

UDC 621.313.333:538.4

MAXIMUM VALUES OF EFFICIENCY OF A CYLINDRICAL MHD PUMP IN AN ELECTRODYNAMIC APPROXIMATION FOR A SMALL NONMAGNETIC GAP

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 85-92 manuscript received 1 Nov 76

VILNITIS, A. YA., and PUKIS, M. V.

[Abstract] This paper discusses an algorithm for estimating the maximum values of the efficiency of cylindrical MHD pumps. A nonlinear programming simulation problem is designed for this purpose, based on two variable parameters without limitations, i.e., all relationships in the form of inequalities are used to reduce the number of variable parameters. Numerical experiments are carried out for two typical liquid metals, sodium and mercury. Studies are made of level lines, efficiency, and other parameters from the viewpoint of a maximum criterion functional. A study is also made of how the algorithm holds up to changes in values of fixed parameters, i.e., to selection of raw data. It is concluded that the simplicity of this algorithm, which consists of solving a simulation problem in a two-dimensional space of variable parameters with a criterion functional, makes it convenient for engineering calculations. This advantage is somewhat offset, however, by a number of shortcomings, which are revealed in the numerical experiments conducted here. The algorithm is inflexible in the face of changes in a number of fixed parameters within limits of tolerance, and in some instances maximum points lie outside the range of applicability with respect to approximating small values of width for the nonmagnetic gap. A number of conclusions of value are nevertheless drawn from the results of the numerical experiments: At 50 Hz design solutions utilizing maximum values presuppose high rates of discharge per unit of width. In designing low-delivery pumps special attention should be devoted to the feasibility of operating with a reduced feed rate. Work should be continued on designs with thin conducting or nonconducting liquid-metal channel walls. The previously held notions of the best power ratings for high-delivery pumps were confirmed, and this fact should be taken into consideration, conditions permitting. Figures 2; tables 5; references 13: 12 Russian, 1 Western.

SOME ELECTROHYDRODYNAMIC FLOWS IN LIQUID DIELECTRICS

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 76-80 manuscript received 26 Dec 75, after correction 23 Apr 76

MIKHAYLOV, A. A., and STISHKOV, YU. K.

[Abstract] In this paper an analysis is made of the Coulomb conductive component of electrodynamic forces in nonconducting fluids with inhomogeneous distribution of ambient conduction. The effect of these conductive forces in nonpolar dielectric fluids is illustrated in three examples. In the first two the electric field is homogeneous and the effect of the dielectric component can be disregarded. In the last the dielectrophoretic and Coulomb components are opposed. In the first two attention is paid to the effect of a homogeneous electric field on a region of high conduction insulated from the electrodes, and in the third to the electric wind from a pointed tip. The experimental setup utilizes acrylic plastic cells and a light projector. The first two experiments utilize transparent vaseline as the insulating fluid. Experiment No 1 demonstrates conductive convection. A drop of vaseline oil prepared from a solution of cherry-red iodine in vaseline oil and representing a fluid with elevated conduction is inserted into the cell filled with clear vaseline oil, through a thin tube into the space in the cell between the electrodes. When one to three kilovolts are fed to the electrodes electroconductive forces form the spherical drop into an ellipsoid extended in the direction of the field's lines of force. This experiment demonstrates that the velocities of conductive flows, which are proportional to the square of the mean field strength, are two to three orders of magnitude higher than ion velocities. Experiment No 2 demonstrates thermoelectroconductive convection. A heating element is inserted into the cell to create a region of elevated temperature, which appears as a spray of fluid rising from the heater. Owing to thermal ionization of the insulating fluid this region of elevated temperature is also the region of elevated conduction. The effect of the Coulomb component of electrodynamic forces on a region of elevated temperature insulated from the electrodes is of an electroconductive nature and pulls this region along the field's lines of force, as is demonstrated in photographs shown here. The rate of horizontal displacement of the head of the "spray" is many times greater than the mean velocity of ion migration. Experiment No 3 demonstrates a fluid moving from a pointed tip and following the direction of action of electroconductive forces, illustrating the case of local elevation of temperature and conduction which arises owing to the Joule heat of a fluid in a region of current concentration near a pin-type electrode. In this case the Coulomb conductive component is directed along the field's lines of force going from the electrode into the fluid, and the dielectrophoretic component is in the opposite direction. The pattern of the electric wind created is illustrated by using castor oil as the fluid filling the cell and introducing air bubbles into it. Features of this wind are described and it is noted that they cannot be explained from the viewpoint of the substantial role of the ambient Joule heat. It is concluded that this does not cause an essential change in the medium's conductivity and is thus not the main reason for electromotive conductive forces. These are apparently due to additional ionization at points of field concentration. Figures 3; references 12: 11 Russian, 1 Western.

THE SHOCK ADIABAT IN ELECTROHYDRODYNAMICS

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 65-68 manuscript received 24 Sep 76

POLYANSKIY, V. A.

[Abstract] A system of relationships at the surface of an electrohydrodynamic shock-wave discontinuity was obtained in an earlier paper. This system was obtained for the case when the flow is stationary, the discontinuity is two-dimensional, and the tangential component of the electric field strength before the discontinuity is equal to zero. In this paper a numerical analysis is made of the possible states of the medium behind the front of the discontinuity with a surface charge of a specific arbitrary value. An example of this type of discontinuity is the discontinuities in charged grids, whose hydrodynamic resistance can be disregarded. An equation is derived which produces a family of shock adiabatic curves which are a function of a dimensionless parameter reflecting the surface charge. This family characterizes electrohydrodynamic discontinuities with specific values of the surface charge. The shock adiabat is a hyperbola. States behind the wave are represented by points of intersection between the adiabatic hyperbolas and a straight line representing the law of conservation of momentum. Features of these states are discussed in detail. It is demonstrated that the mass flux through the surface of the discontinuity can not be lower than a specific limit. This is similar to the situation encountered in studying the detonation adiabat in gas dynamics, when the amount of matter burning per unit of time per unit of surface area of the detonation wave can not be below a certain limit. A diagram is shown indicating four different types of discontinuities, the number of different types of waves sent out by a discontinuity, and the number of key relationships at the front of the discontinuity. The interrelationship between these factors is discussed, as is, in particular, the evolution of different types of discontinuities with reference to shortwave and high frequency disturbances, i.e., of discontinuities permitted by the shock adiabat given here and a specific surface charge. Figures 5; references 4 (Russian).

THE INFLUENCE OF A MAGNETIC FIELD ON TURBULENCE IN TWO-DIMENSIONAL FLOW OF A HIGH-TEMPERATURE MEDIUM

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 61-64 manuscript received 25 Oct 76

LEVITAN, YU. S.

[Abstract] In this paper expressions are obtained for eddy viscosity and heat flux during channel flow of an electroconductive medium with current along the axis of the channel in an external magnetic field, taking fluctuations in the temperature of the medium into account. Prandtl's hypothesis and hypotheses on local isotropic turbulence serve as a framework. Anisotropy of turbulence brought about by application of the external magnetic field is furthered by fluctuations in temperature, which cause fluctuations in conduction. The effect of fluctuations in temperature should be taken into account especially in the case of flows with bulk release of heat from the electric current flowing through or in the presence of chemical reactions. A theoretical analysis is given here of the case of flow of an electroconductive medium in an external magnetic field in the presence of Joule heat liberation from the electric current flowing through the channel and spread evenly over its cross section. A formula is given for the pulsation force per unit of volume without taking the Hall effect into account nor the internal magnetic field of the current, and with low magnetic Reynolds numbers, when it is possible to disregard pulsations of the magnetic field. Expressions are given for components of this pulsation force during two-dimensional flow for three different orientations of the external magnetic field. Fluctuations in conduction are expressed through fluctuations in temperature. Formulas are derived for eddy viscosity with different orientations of the external magnetic field. Similar formulas are obtained for turbulent heat flux. Taking fluctuations in temperature into account practically always (except in the case of steady-state flow in a longitudinal magnetic field) results in an increase in the influence of the magnetic field on turbulence. It is emphasized that the expressions obtained here for eddy viscosity and heat flux are correct only in relatively weak magnetic fields, when the model of local isotropic turbulence is valid. References 6 (Russian).

MHD FLOWS DURING FLOW OF AN ELECTRIC CURRENT IN AN AXISYMMETRIC LAYER OF FINITE THICKNESS

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 55-60 manuscript received 22 Dec 76

BOYAREVICH, V. V., and SHARAMKIN, V. I.

[Abstract] This paper is concerned with a theoretical discussion of axisymmetrical motion of a conducting fluid in a two-dimensional infinite layer of finite thickness, aroused by electric current in an internal magnetic field. The current flowing through the layer is created by a field proportional to its radius. A diagram for flow of current under these conditions is shown. A specific precise solution is found to the Navier-Stokes equations for this case. Experimental data are given, relating to characteristics of flow in a two-dimensional layer of finite radius and thickness set into motion by an electric current passing through. Experiments were made with a mercury model, using two extreme cases of current flow: 1) when the central electrode is located at the level of the top base, and 2) when the central electrode is immersed in the mercury as far as the bottom base. Copper-tip electrodes were used, and the faces of the container were made of acrylic plastic. A water jacket was used for cooling. The influence of the magnetic field produced by the leads was disregarded and special attention was paid to the symmetry of the current conductor. Measurements were made of the distribution of pressure over the bottom base in relationship to the value of the current passed through. The distribution of pressure with respect to radius with different current values agrees well with the flow patterns derived by calculation. Motion corresponds to the nature of pressure distribution. Diagrams showing the typical distribution of pressure over the lower base in relationship to the current with both positions of the central electrode are shown. These agree well with hydrodynamic lines plotted for current in the theoretical study. Figures 4; table 1; references 6 (Russian).

INFLUENCE OF A MAGNETIC FIELD ON THE NATURE OF PROPAGATION OF SHEAR DISTURBANCES IN DILATENT MEDIA

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 51-54 manuscript received 14 Sep 76

GRANIK, I. S.

[Abstract] Shear disturbances in dilatant fluids with a power rheological law relating the stress tensor deviator to the strain rate tensor are propagated at a finite rate, and an external transverse magnetic field reduces the speed

of the shear wave's front and in some instances results in stopping the front. In this paper these facts are generalized for a wider class of non-self-similar movements of dilatant media in a transverse magnetic field whose induction varies with time. Calculations are made using as a starting point the magnetic rheology equation describing two-dimensional movement of this sort in the absence of induction. Calculations confirm the fact that the rate of propagation of shear disturbances of a conducting fluid in an external magnetic field is lower than in the absence of this field, and that this rate is finite. The determining factor for the existence of this effect is the rheological properties of the medium, regardless of whether it is a conducting medium or not. For the case of the availability of finite raw data criteria are found for the finite rate of propagation and localization of shear disturbances. Calculated results are confirmed by the experimentally established fact that effective viscosity in dilatant fluids depends on the velocity gradient and returns to zero at the front of the shear wave. The nonlinear effect of three-dimensional localization of shear disturbances, which is naturally associated with the finite rate of propagation of these disturbances, is observed only in conducting media and is due to the influence of an external transverse magnetic field. The nature of variation in the external magnetic field's induction with time influences the velocity of the front by retarding it. The results obtained here agree with earlier data. References 9 (Russian).

USSR

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ANALOGY BETWEEN THERMOCONVECTIVE AND MAGNETOHYDRODYNAMIC INSTABILITY

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 42-44 manuscript received 2 Nov 76

VALDMANIS, YA. YA., and KUKAYNIS, O. A.

[Abstract] It is possible that the various forms of instability observed in the operation of MHD pumps and generators at high rates of output are associated with magnetic cavitation, although this needs to be verified experimentally. Calculations have shown that instability due to electromagnetic forces can occur only in systems with sufficiently great geometrical dimensions or which employ powerful magnetic fields. This paper draws analogies between phenomena of instability observed in heat convection in variable and steady heat fields, and of instability observed in electromagnetic convection in variable and steady electromagnetic fields. Particular attention is paid to the hypothesis of "bubble" instability, which can occur in a variable magnetic field in MHD systems. Intense heating of a layer from below can cause a fluid with gas "bubbles" (metal vapors), which take the shape of filaments extended along the magnetic field and whose internal pressure is created by fluctuations in this field. A circular current then pulsates around these filaments. These filaments can cause instability if they do not disappear quickly enough. An example of calculations taking this phenomenon into account is given,

applying results obtained from the theory of the flow of a fluid containing small gas bubbles. Gas bubbles will appear with high temperature gradients. These bubbles will be spherical in the absence of an external magnetic field. Instability arises in heating from below, when the lower layers become lighter owing to formation of bubbles in them. The density gradient then reaches a critical value. This instability can also arise in the boundary layers at the interface of two phases, where both the temperature and electromagnetic fields can have large gradients. The possibility of this type of instability occurring should be taken into account in designing high-power MHD machines. References 17: 13 Russian, 4 Western.

USSR

UDC 532.574.6:538.4

TECHNIQUE AND RESULTS OF A STUDY OF CONDUCTION-TYPE MEASUREMENT TRANSDUCERS

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 119-123 manuscript received 23 Jul 76

DUNAYEVSKIY, I. G., KOROTKOV, B. N., POVKH, I. L., and CHEPLYUKOV, V. G.

[Abstract] This paper gives the results of studies of the metrological characteristics of conduction-type measurement transducers which make it possible to make measurements in both low-turbulence and high-turbulence flows. These transducers consist basically of the poles of a magnet with a slit-type gap between them which functions as the device's working area. The poles and the gap have been made small enough to shift the magnetic lines of force into the area in front of the probe tip, and this area now functions as the device's working area. A further modification is represented by the fact that the electrodes are not located in the gap but project onto the surface of the probe with their faces turned toward the velocity vector of the oncoming flow. This type of probe makes it possible to measure the longitudinal component of the pulsation velocity. Conduction-type measurement transducers require preliminary calibration with a standard pulse rate meter. A technique suggested previously proved unsatisfactory, in that it did not take the difference in three-dimensional resolution and frequency characteristics between the transducer and the meter into account. This paper suggests a method of calibration which is frequency dependent, i.e., which tests transducer sensitivity within narrow frequency bands. The mean sensitivity for all bands is then found, using 1/3-octave filters. Special requirements are imposed on the flow in the test unit, since calibration is performed by comparing readings on a standard meter. Dimensions of the flow should be such that the structure of the flow is not distorted when the probe is inserted. Large-scale turbulence is necessary to determine the probe's sensitivity over as wide a frequency range as possible. A hot-wire anemometer with a film-type measuring probe is the most acceptable reference meter. Calibration was performed in a closed type water tunnel and on a hydrodynamics testing bench. Studies were made of conduction-type probes of different diameters, with different distances between electrodes, and with tips of different shapes. Sensitivity

and three-dimensional resolution served as the criteria for plotting metrological characteristics. Sensitivity for all types fell within the range of 0.7 to 3.5 $\mu\text{V}/(\text{mm}/\text{s})$. Sensitivity can be increased by increasing the dimensions of the magnetic system or the gap between electrodes. The maximum spread in sensitivity with different degrees of turbulence is not greater than 10 percent. Sensitivity in 12 probes of the same type differed no more than 13 percent from one to the other, which was due mainly to differences in field distribution owing to the magnetic systems used. Reducing the circular radius of the tip results in a marked improvement in resolution. Figures 5; references 5 (Russian).

USSR

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ESTIMATING THE PRESSURE DEVELOPED BY A HIGH-TEMPERATURE LOOP-TYPE PUMP FOR PUMPING LIQUID METALS, WHICH UTILIZES THE DRIVING POWER OF A MAGNETIC FIELD CREATED BY CONDUCTORS CARRYING CURRENT

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 124-126 manuscript received 20 Oct 76

ZEMLYANKIN, V. A., KONIN, M. K., and SHILOV, G. V.

[Abstract] In this paper a calculation is made of the pressure developed by a pump for liquid metals used in making corrosion-resistance tests of construction materials in a flow of liquid metal. This pump is a loop-type pump which utilizes the driving effect of interaction between two liquid conductors carrying current. These conductors are at an arbitrary angle to one another. The loop is heated to the operating temperatures required by the induction method, by passing the circuit's loop around the magnetic core of a step-down transformer. An electromagnetic force which propels the liquid metal is created by interaction between the magnetic fields of the conductors and the current induced in them. Creation of this force is discussed in detail. Formulas are derived for calculating the motive force, and the pressure developed by the electromagnetic force is determined by the relationship between this force and the area of the tube's cross section. The expression for this relationship utilizes a factor for matching the theoretical and experimental pressure developed by the pump. This factor takes into account the fact that the sum current vector does not fall in line with the tube's axis, and the angle thus formed varies. The value for this factor arrived at here is less than zero since this angle was taken at its maximum value in making the calculation here. Figures 4; references 2 (Russian).

STUDY OF CROSS CORRELATION COEFFICIENTS OF TEMPERATURE FLUCTUATIONS IN A LONGITUDINAL MAGNETIC FIELD

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, 1977 pp 136-137 manuscript received 8 Jun 76

GENIN, L. G., MANCHKHA, S. P., and SVIRIDOV, V. G.

[Abstract] A previous paper by these authors was devoted to a study of the influence of a longitudinal magnetic field on the statistical characteristics of turbulent fluctuations in temperature when mercury flows in a round tube, including its influence on correlation coefficients in the transverse direction. But the influence of the magnetic field on cross correlation coefficients could not be traced fully owing to the fact that they were measured with a comb-type probe for only one value of the radial coordinate, for one thing. More detailed experimental data relating to this question are obtained in this paper. Experiments were conducted with the same mercury circuit used in the previous study. Two three-lead copper-and-constantan thermocouples served as temperature sensors. Signals from these thermocouples were amplified and fed to a DISA model 55D70 correlometer, by means of which a determination was made of the cross correlation coefficient. A diagram shows the change in correlation coefficients when the magnetic field is applied. When the cross dimension is approximately equal to 1 mm there is no observable difference in correlation coefficients with and without the magnetic field. When the cross dimension exceeds 1 mm this difference is quite noticeable. The influence of a magnetic field on the cross correlation coefficient differs in the center of the tube and at its wall. It is lower in the center and higher at the wall, thus proving that the lack of uniformity in cross ranges of temperature fluctuations over the tube's cross section increases in a magnetic field. The change in the cross correlation coefficient under the influence of a magnetic field is not as great as that of the longitudinal correlation coefficient under this same influence. The latter are drastically higher in a longitudinal magnetic field, making the structure of the temperature field more anisotropic and resulting in an increase in the scope of turbulent disturbances in the direction of the magnetic field's lines of force. Figures 1; references 2 (Russian).

USSR

UDC 621.313.12:538.4

STUDY OF THE PECULIARITIES OF THE AERODYNAMIC ORGANIZATION OF THE WORKING
PROCESS IN A CONICAL COMBUSTION CHAMBER FOR AN MHD INSTALLATION

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 15 No 3, May/Jun 77 pp
629-634 manuscript received 27 Apr 76

DVOYNISHNIKOV, V. A., and LARYUSHKIN, M. A., Moscow Power Engineering Institute

[Abstract] Experimental studies were performed in a combustion chamber model geometrically similar to the combustion chamber of the U-25 installation of the Institute of High Temperatures, Academy of Sciences USSR, under isothermal conditions. The methodology of investigation and processing of the results called for measurement of static and dynamic pressures and temperatures in the volume of the chamber. Analysis of the fields of isotachs and isotherms in the volume revealed the mechanism of interaction and the peculiarities of the structure of the flow. The physical flow picture can be represented as follows: jets leaving the slits of the side combustors propagate radially, first with mixing, then with full or partial rotation in the direction of the output of the chamber. Sometimes, some of the jets are directed toward the prechamber, forming a vortex zone. As they move, they merge to form a central zone. The flow from the prechamber interacts with the jets around the perimeter. A method is suggested for calculation of the aerodynamics in the chamber. References 4 (Russian).

USSR

UDC 533.932

THE QUESTION OF THE EFFECTIVE CONDUCTIVITY OF A HETEROGENEOUS PLASMA (NON-
LINEAR IONIZATION WAVES)

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 15 No 3, May/Jun 77 pp
486-495 manuscript received 20 Apr 75

DMITRIYEV, A. S., and SINKEVICH, O. A., Moscow Power Engineering Institute

[Abstract] The effective conductivity of a low-temperature nonequilibrium magnetized plasma in a heterogeneous state due to the development of ionization instability is discussed. Existing methods of calculation of effective conductivity are compared, and using an approach developed earlier by one of the authors for construction of nonlinear waves and the principle of "hyperstability" introduced by the authors, a closed theory is constructed, allowing the effective conductivity of a heterogeneous plasma to be calculated within the framework of the nonlinear theory of plane waves. The advantage of this approach is that an equation can be developed (frequently called "semiempirical") which agrees well with the experimental data over a broad range of plasma parameters, is based on the minimum number of assumptions and leaves no free parameters. References 24: 20 Russian, 4 Western.

USSR

STATIONARY SPECTRA OF HIGH-FREQUENCY OSCILLATIONS OF A PLASMA IN A MAGNETIC FIELD

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 72 No 5, May 77 pp 1783-1796 manuscript received 14 Sep 76

BREYZMAN, B. N., MALKIN, V. M., and SOBOLEV, O. P. (deceased), Institute of Nuclear Physics, Siberian Division of the USSR Academy of Sciences

[Abstract] Instability of a relativistic electron beam in a plasma in a weak magnetic field ($\omega_{He} \ll \omega_{pe}$) is considered. The electron beam excites Langmuir oscillations of the plasma, the amplitude of which is limited due to induced scattering of waves by ions as well as due to Coulomb collisions between plasma particles. Scattering causes a shift away from resonance and the "magnetic" component of the frequency deviation is considered here to be much larger than the "thermal" component ($\omega_{He} \gg \omega_{pe} \omega_T / mc^2$). As a result, a stationary turbulence can be sustained. Its spectrum and parameters are estimated here on the basis of the fundamental equations of weak turbulence, assuming that the frequency variations are much narrower than the spectrum. Nonresonant regions are classified with respect to the frequency range within which the dispersion law remains a quasipower law. This applies to a beam of Langmuir waves traveling across the magnetic field, a beam of Langmuir and transformed (to electromagnetic) waves polarized transversely with respect to the magnetic field, and to such waves traveling obliquely. A degenerate spectrum is also possible. The resonance region depends on the source and on the boundary conditions. In this case the plasma heating power is calculated here as a function of the magnetic field intensity. Figures 5; references 12 (Russian).

USSR

BREMSSTRAHLUNG OF RELATIVISTIC ELECTRONS IN A PLASMA IN A STRONG MAGNETIC FIELD

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 72 No 5, May 77 pp 1824-1832 manuscript received 19 Oct 76

AKOPYAN, A. V., and TSYTOVICH, V. N., Institute of Radiophysics and Electronics, Academy of Sciences of the Armenian SSR

[Abstract] The general theory of bremsstrahlung in a plasma is extended to the case of a strong and constant external magnetic field with relativistic thermal and ultrarelativistic hyperthermal electrons radiating while moving along the magnetic lines of force. The fundamental relations are derived from the Maxwell equations for Fourier components of the electric field intensity and the current, yielding here a single Green's function. Furthermore, the shielding effect of the plasma on ordinary bremsstrahlung as well as

the transient mode of bremsstrahlung are calculated. It is shown that in a strong magnetic field the effects of dynamic shielding strongly attenuate the intensity of ordinary bremsstrahlung at high frequencies $\omega \ll \omega_{\max}; \omega_{\max} = 2\gamma^2 \omega^*$, where $\omega^* = \omega_{pe} c / v_{Te}$, ω_{pe} is the electron plasma frequency, $\gamma = \varepsilon / m_e c^2$, ε is the energy of a relativistic electron, v_{Te} is the mean thermal velocity of plasma electrons ($v_{Te} \ll c$). References 17: 10 Russian, 7 Western.

USSR

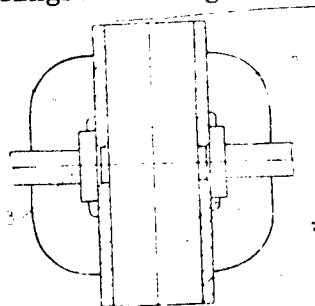
UDC 669.295:621.313.29:538.4

AN MHD CONDUCTION PUMP FOR MAKING TITANIUM ALLOY CASTINGS

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 1, Jan/Mar 77 pp 139-140 manuscript received 21 Apr 76

VASENIN, V. I., KOVALEV, YU. G., and MEL'NIKOV, V. S.

[Abstract] The paper describes a conduction MHD pump of DC type that is used in making titanium alloy castings. A diagram of the pump is shown in the figure.



The unit is made up of channel 2, polepieces 4, coil 1 and current leads 3. The working section of the channel measures 23.5 x 65 mm. A pressure of up to 2.5 kgf/cm² is developed in the molten metal. The working time is determined by the time it takes for the casting to set up (10-30 s). The authors give the results of studies of the magnetic system of the pump. The composition of the mixture for making the channels is presented as well as the manufacturing technique. The results of studies of processes that take place in the channel are given. Modes of pump operation when teeming and crystallizing castings are considered. The particulars of designing conduction pumps for casting titanium alloys are examined. These pumps are now being introduced into Soviet industry. Figures 6; references 4 (Russian).

USSR

ABSORPTION OF ELECTROMAGNETIC WAVES IN PLASMA IN THE PRESENCE OF A QUANTIZING
MAGNETIC FIELD

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 72
No 4, Apr 77 pp 1613-1618 manuscript received 29 Jun 76

KOLESOV, V. V., Ural State University imeni A. M. Gor'kiy

[Abstract] An expression is found for the effective frequency of electron-ion collisions in the region of weak spatial dispersion for a system of particles with Coulomb interaction (electron-ion plasma) located in a strong (quantizing) magnetic field in the presence of a high-frequency alternating electromagnetic field. It is shown that the effective frequency of electron-ion collisions in a quantizing magnetic field has a tendency to decrease at low frequencies of oscillations of the field, whereas at high frequencies the collision rate cannot be changed either by the influence of the magnetic field or the temperature. The author thanks V. V. Dyakin for discussing some mathematical aspects of this work, as well as A. A. Rukhadze for support and discussion of the results. References 6 (Russian).

USSR

CLASSICAL APPROXIMATION FOR IONIZATION OF A NEGATIVE ION BY AN ELECTRON IMPACT NEAR THE THRESHOLD

Moscow ZHURNAL EKSPERIMENTAL'NOY I THEORETICHESKOY FIZIKI in Russian Vol 72 No 6, Jun 77 pp 2072-2078 manuscript received 7 Dec 76

SOLOV'YEV, YE. A., Leningrad State University

[Abstract] An analysis is made of the classical model of ionization of a negative ion by electron impact near the threshold. In the classical statement, the problem is divided into two problems: The solution of the equations of motion and statistical processing of the results. The interaction of a weakly bound electron from a negative ion with a neutral ion fragment is modeled by a briefly acting potential. At incident electron velocities less than the velocity of the weakly bound electron within the short-range potential the problem is solved completely analytically. The reason that the simple classical approach yields approximately the same results as the rather complex quantum-mechanical approach is apparently that there is a critical dependence of ionization cross section near the threshold on the selection of the trajectory of the incident electron. In the quantum-mechanical approach it is difficult to consider the coulomb interaction in all portions of the problem, whereas in the classical approach this is quite simple and natural. References 11: 8 Russian, 3 Western.

USSR

UDC 533.9.082

STUDY OF A MODEL OF A DENSE, WEAKLY IONIZED MERCURY PLASMA BY THE METHOD OF MOLECULAR DYNAMICS

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 15 No 3, May/Jun 77 pp 645-647 manuscript received 28 Jun 76

LAGAR'KOV, A. N., and SARYCHEV, A. K., Institute of High Temperatures

[Abstract] The specific properties of a dense, weakly ionized mercury plasma are determined by the interaction between the electrons and the neutral atoms. Within the framework of this assumption, this work utilizes the method of computer simulation to determine the conductivity of a dense, weakly ionized mercury plasma in the subcritical region. Two possibilities were studied: the atoms do not interact, as in an ideal gas, or the atoms do interact as solid spheres. In the latter case, the diameter of the atoms was considered equal to the gas-kinetic diameter. As temperature decreases, the conductivity maximum corresponding to the characteristic frequency of isolations of the electrons in a cluster is clearly seen. A typical cluster at a density of 1.61 g/cm^3 contains about 20 particles, resulting in a broad spectrum of electron vibration frequencies in the cluster. Such a cluster includes many bound electron states, justifying the classical approach to the problem electron motion. References 7: 5 Russian, 2 Western.

USSR

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SUPERCONDUCTING AND CRYOGENIC DEVICES IN THE ACCELERATING SECTION OF A COLLECTIVE FIELD ACCELERATOR. I.

Leningrad ZHURNAL TEKHNIЧЕСКОЙ ФИЗИКИ in Russian Vol 46 No 6, Jun 77 pp 1213-1221 manuscript received 8 Jan 76

AGEYEV, A. I., ANISHCHENKO, N. G., BALLAYKIN, N. I., BALANDINKOV, N. I., BEKETOV, V. V., BELUSHKINA, A. A., BYCHKOV, N. S., VOLKOVYSKIY, E. V., VOLKOV, V. YA., DANILOV, V. V., ZHITNIKOV, B. Z., ZEL'DOVICH, A. G., ZEL'DOVICH, N. K., ZINOV'YE, L. L., KATRASEV, V. V., KRYULOV, V. V., LACHINOV, B. M., LUR'YE, S. I., MATVEYEV, E. V., MENKE, KH., MURATOV, YU. V., RUBIN, N. B., SARANTSEV, V. P., SMIRNOV, YU. I., TSVINEVA, G. P., SHABRATOV, V. G., and SHISHOV, YU. A.

[Abstract] The Joint Institute for Nuclear Research has been working on the creation of accelerating systems for a collective-field ion accelerator for several years, including the "kol'tsetron" cryogenic high-frequency section. Most of the installation work is completed; testing and modernization are now underway. In this article, the basis is presented for the selection of the superconducting elements (resonators, solenoids) of the kol'tsetron and the elements are described. The peculiarities of the refrigeration system are analyzed. Data are presented on the required magnetic field structure and the magnetometry system used. Photographs are presented of one-half of a cylindrical resonator, covered with an atomized niobium-titanium film and of a resonator module of the kol'tsetron. References 13 (Russian).

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RESULTS OF CERTAIN EXPERIMENTAL STUDIES OF THE SUPERCONDUCTING HIGH-FREQUENCY ACCELERATING SECTION OF A COLLECTIVE FIELD ACCELERATOR. II.

Leningrad ZHURNAL TEKHNIЧЕСКОЙ ФИЗИКИ in Russian Vol 46 No 6, Jun 77 pp 1222-1224 manuscript received 8 Jan 76

AGEYEV, A. I., ANISHCHENKO, N. G., BALALYKIN, N. I., BEKETOV, V. V., BYCHKOV, N. S., VOLKOVYSKIY, E. V., ZEL'DOVICH, A. G., KRYLOV, V. V., LACHINOV, V. M., MURATOV, YU. V., RUBIN, N. B., SARANTSEV, V. P., SMIRNOV, YU. I., TREYBALOVA, ZH. V., SHABRATOV, V. G., and SHISHOV, YU. A.

[Abstract] This work, a continuation of the article on pages 1213-1221 of this same publication, in which the description and main parameters of the "kol'tsetron" accelerating section of a collective-field ion accelerator were presented, reports on the results of experiments involving measurement of the Q of the superconducting niobium-titanium resonator, the distribution of the magnetic field in the cross section created by the superconducting solenoids and the characteristics of the superconducting cable used. Data on heat flow to the units of the section and the process of evacuation of energy are presented. In most cases, heat influx was significantly above the design level.

Future work on the kol'tsetron will be directed toward improvement of the cryogenic systems in order to reduce this heat influx. Work is continuing on the model resonators to determine the optimal composition of the superconductor and find the optimal heat treatment of the superconducting coating. Plans have been made to increase the Q of the resonators to 10^8 and problems of their operation under conditions such that the magnetic field in the central area of the resonators will be about 2T are being studied. References 2 (Russian).

USSR

CHARGE TRANSFER IN PLASMA

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 72 No 6, Jun 77 pp 2044-2047 manuscript received 15 Nov 76

ZHDANOV, V. P., KVLIVIDZE, V. A., and CHIBISOV, M. I., Scientific Research Institute for Nuclear Physics, Moscow State University

[Abstract] Charge transfer is usually considered a binary process. Actually, if charge transfer in a plasma is considered, i.e., in a medium in which electrons are present, ternary collisions must be considered, collisions of the transferring pair with an electron of the medium. It is shown that these collisions, under certain conditions, greatly increase the cross section of non-resonant charge transfer and compensate for the decrease in cross section of resonant charge transfer resulting from coulomb disorders. Ternary collisions become significant with electron densities of 10^{12} cm^{-3} . Using an Rb-Cs plasma as an example, it is shown that with an atomic velocity of about 10^6 cm/s , and electron velocity of about $7 \cdot 10^7 \text{ cm/s}$, resonance defect $K_0 \approx 0.28 \text{ eV}$, the cross section for electron induced transfer is about $3 \cdot 10^{-32} n_e \text{ cm}^2$, which is 10^3 times greater than the charge transfer cross section calculated considering coulomb detuning. A figure shows the variation in charge transfer cross section with electron density. The effect of the influence of electrons in the medium on charge transfer must be considered in measuring charge transfer cross sections in a plasma in the adiabatic range of velocities. References 5 (Russian).

USSR

SEARCH FOR FRACTIONALLY CHARGED PARTICLES IN SEA WATER, OCEANIC BOTTOM SEDIMENTS, AND VOLCANIC LAVA

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 72 No 5, May 77 pp 1633-1639 manuscript received 24 Aug 76

OGORODNIKOV, D. D., SAMOYLOV, I. M., and SOLNTSEV, A. M., Institute of Atomic Energy imeni I. V. Kurchatov

[Abstract] According to M. Gell-Mann and G. Zweig, there may exist fundamental elementary particles with fractional charges (quarks). In this study such particles were sought in samples of sea water, iron-manganese deep-sea concretions, fine-disperse deep-sea clays, radiolarian ooze with foraminifera, and volcanic lava. A special apparatus has been designed and built for collecting quarks which contains an electric filter and a trap. It operates on the principle of thermal desorption, but the performance is limited by erosion and diffusive scattering of particles due to their surface ionization at the electrodes or due to recharge in the gas. A quantitative analysis and identification of actual samples with the aid of a mass spectrometer yielded negative results in this search for quarks, thus further diminishing the probability of their existence in the free state, on the basis of estimated upper limits of their concentrations ($5 \cdot 10^{-28}$ – $6 \cdot 10^{-25}$ quark/nucleon). Figures 3; tables 2; references 13: 5 Russian, 8 Western.

USSR

INELASTIC SCATTERING OF LIGHT IN VAPORS OF ALKALI METALS. MOLECULAR FLUORESCENCE

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 72 No 5, May 77 pp 1738-1748 manuscript received 20 Aug 76

BONCH-BRUYEVICH, A. M., PRZHIBEL'SKIY, S. G., and KHROMOV, V. V.

[Abstract] Two possible processes convert the motion of a pair of colliding atoms from infinite to bound. The first occurs when two unexcited atoms collide and form an excited molecule. The second occurs when an excited atom collides with an unexcited one and, while a photon is emitted spontaneously, both form a molecule. Measurements were made in saturated vapors of cesium and rubidium: the intensity of fluorescence as a function of the excitation intensity, the excitation supplied from a neodymium laser ($\lambda = 1060$ nm) or from a tunable organic dye laser ($\lambda = 852.1$ nm) respectively. The resulting fluorescence spectra and the appearance of new peaks (697 and 729 nm in the cesium spectrum) are analyzed here in terms of the simplest model of quasi-bound motion and classical "orbiting." Figures 7; references 11: 5 Russian, 6 Western.

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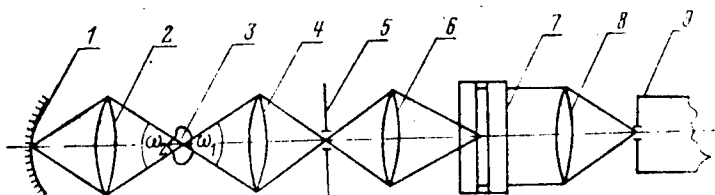
UDC 533.9.082

DETERMINATION OF THE CONCENTRATION OF ATOMS IN A PLASMA

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 26 No 3, Mar 77 pp 413-416 manuscript received 5 Jan 76

BARANOVA, I. D., and TSKHAY, N. S.

[Abstract] A technique is proposed for determining the integral absorption, which can then be used for calculating the concentration of atoms in a plasma, by exposing a source of emission to its own reflected light.



The optical arrangement is shown in the diagram. Lens 2 with focal length of $F = R/2$, where R is the radius of curvature of mirror 1 is placed at the center of curvature of the mirror at a distance $2F$ from the investigated light source 3, ensuring that the source is transilluminated by light that is reflected from the source itself. Lens 4 forms an intermediate image of source 3 in the plane of iris 5, which isolates the required section of the image.

Angle ω_2 must not be larger than ω_1 to avoid iris-ing of reflected rays from the mount of lens 4. Fabry-Perot interferometer 7, which gives the contour of the investigated line, is placed in the converging pencil of rays framed by lens 6, and interference rings localized at infinity are focused on the input slit 9 of an ISP-28 spectrograph by achromat 8. The proposed technique was checked out in an AC arc. The electrodes were made from an alloy of copper with small known amounts of zinc. The zinc concentration was determined from emission on line Zn 307.6 nm. The results agree satisfactorily with measurements by the Ladenburg-Reiche linear absorption method. Figures 2; references 5: 4 Russian, 1 Western.

USSR

UDC 535.34

SPECTRAL AND INTEGRAL EMITTANCES OF A HEATED MIXTURE OF 97% CO₂ AND 3% N₂

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 26 No 5, May 77 pp 944-947 manuscript received 21 Jan 77

NIKOLAYEV, V. M., and PLASTININ, YU. A.

[Abstract] In the book "Radiation Properties of Gases at High Temperatures" [Moscow, "Mashinostroyeniye," 1971], V. A. Kamenshchikov, Yu. A. Plastinin, V. M. Nikolayev and L. A. Novitskiy give the results of calculations of the optical characteristics of heated gases, including air, and also CO₂, 90% CO₂ + 10% N₂, and 16% CO₂ + 84% N₂. In this paper similar calculations are done for a mixture of 97% CO₂ and 3% N₂, which present data show to be close the composition of the atmosphere of Venus. In calculating optical characteristics, the authors consider molecular spectra averaged with respect to rotational structure, and take detailed consideration of their vibrational structure. The integral and spectral emittances and the spectral coefficients of absorption are calculated in the wavelength range of 0.02-4 μ m at temperatures of 6,000-12,000 K and pressures of 0.1, 0.3 and 1 MN/m². The authors thank G. G. Baule and A. N. Krasnokutskaya for assistance with the calculations. Figures 3; references 10: 5 Russian, 5 Western.

USSR

UDC 533.95:538.4

PECULIARITIES OF THE EXPANSION OF CONDENSED SUBSTANCES AFTER THEY ARE STRUCK BY POWERFUL SHOCK WAVES

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 15 No 3, May/Jun 77 pp 449-455 manuscript received 24 Dec 75

RUSAKOV, M. M., IVANOV, R. I., SHAYDULLIN, B. K., and SHPAK, S. G.

[Abstract] An earlier work discovered that when paraffin and tungsten expand after a powerful shock wave has traveled through them, there is a region of anomalous expansion of the substances as their thermal energy increases. In order to further study this anomaly, experiments were performed on the expansion of lithium hydride, paraffin, teflon, magnesium, copper, molybdenum, bismuth, lead, tantalum and tungsten. The substance being studied was placed in the form of a plug 5 mm in diameter and 5.5 mm high or a disk (for the heavier substances) 5 mm in diameter and 0.5 mm high against a paraffin plug 5.5 mm high at the beginning of a cylindrical channel 5 mm in diameter. The cylindrical channel was 60-200 mm in length, after which it became conical with an angle of 10 or 30 degrees. The length of the expanding channel at 10 degrees was 100 mm. The velocity of the shock wave striking the paraffin plug was 33 km/s, for the lithium hydride plug--36 and 44 km/s. The heavier substances in disk form were accelerated by the shock wave leaving the paraffin plug. The channels contained ordinary air. The movement of the shock wave propagating in the air in front of the substance was recorded by a photochronograph. The results of this were confirmed and supplement the data on the anomalous expansion of substances with increasing thermal energy and temperature found earlier. It is found that after transmission of powerful shock waves imparting energies of tens or hundreds of eV/atom, the substance, in a certain range of parameters, expands with increasing thermal energy and temperature. These peculiarities of expansion have been interpreted as manifestations of phase transitions in a highly ideal plasma. References 8 (Russian).

USSR

UDC 533.9.15

PHASE TRANSITION PHENOMENON IN A DENSE CAPILLARY DISCHARGE PLASMA

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 15 No 3, May/Jun 77 pp 456-463 manuscript received 31 Dec 75

OGURTSOVA, N. N., PODMOSHENSKIY, I. V., and SMIRNOV, V. L.

[Abstract] A study is made of a dense quasisteady-state plasma produced by an open-ended capillary discharge with wall evaporation. In such a discharge based on C_2H_3Cl and $C_{37}H_{47}O_{16}$ at $T = 40,000$ K and $n_e + n_i \cdot 10^{20} \text{ cm}^{-3}$, a plasma is produced corresponding to an isotherm which has pressure jumps of up to $2 \cdot 10^7 \text{ N/m}^2$. The results show appreciable departure from $P = nkT$ and are interpreted as a phase transition in a highly ideal plasma. The phase transition may be related to multiply charged ions, particularly C^{2+} and Cl^{2+} . The most general property of this plasma is its capacity for self-compaction. Other facts are considered that show the unusual nature of the plasma object. An attempt is made to distinguish the effects that are due to the specific properties of the source used. The phase transition detected may occur in other high temperature plasma sources, particularly in discharges under water, where the increase in pressure and temperature are retarded with an increase in input energy and the experimental pressure rise rate is lower than the calculated rise rate. However, there is almost no evidence of phase precipitation in conductivity and blackbody radiation of the plasma, and therefore it can be detected only by analysis of independent diagnostic data on temperature, pressure and density. References 17 (Russian).

USSR

UDC 533.9.01

A ONE-DIMENSIONAL THEORY OF CAPILLARY DISCHARGE WITH EVAPORATING WALLS

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 15 No 3, May/Jun 77 pp 465-470 manuscript received 16 Dec 75

BONDAREV, B. V., MURAVENKO, V. G., and SHUROKOV, M. F., Moscow Aviation Institute imeni S. Ordzhonikidze

[Abstract] A capillary discharge with evaporating walls is a convenient model for experimental studies of plasma sources. In this article, based on the equations of gas dynamics, a one-dimensional theory of such a discharge is developed. The variations in density, enthalpy, radiation path length and resistivity with pressure and temperature, found by numerical methods considering elementary processes in the plasma, are approximated by simple interpolation formulas. Formulas are derived for calculation of the pressure and temperature of a plasma in the middle and at the end of the capillary tube with fixed diameter and discharge current. The applicability of the formulas at

high temperatures and low pressures is limited by the transition from radiant to electronic thermal conductivity. References 8 (Russian).

USSR

UDC 539.9:536.71:546.36

EXPERIMENTAL EQUATION OF STATE OF A HIGHLY IONIZED CESIUM PLASMA

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 15 No 3, May/Jun 77 pp 471-477 manuscript received 4 Feb 76

DIKHTER, I. YA., and ZEYGARNIK, V. A., Institute of High Temperatures, Academy of Sciences

[Abstract] Earlier reports have published the basic results of studies of a dense, highly ionized cesium plasma by the method of electric explosion of wires in an inert gas atmosphere at up to 500 atm. In this work, these results are presented in more detail, with a more complete procedural basis and the experimental results are compared in more detail with results calculated using the model of an ideal doubly ionized cesium plasma. The technique involves the electric explosion of a cesium wire in an atmosphere of argon, measurement of variation in current in the circuit, voltage drop across the discharge gap and diameter of the discharge column with time at constant pressure. The plasma temperature is 10,000-36,000 K, degree of ionization varying from 0.3 to 1.5. An equation of state of an ideal doubly ionized cesium plasma is calculated. The experimental caloric equation of state agrees well with the calculated equation. References 14: 10 Russian, 4 Western.

USSR

UDC 536.41:546.883+669.294.5'27

EXPERIMENTAL STUDY OF THE THERMAL EXPANSION OF A NUMBER OF STRUCTURAL MATERIALS. TANTALUM AND THE TANTALUM-TUNGSTEN ALLOY TV-10

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 15 No 3, May/Jun 77 pp 534-538 manuscript received 30 Jun 75

PETUKHOV, V. A., CHEKHOVSKOY, V. YA., and MOZGOVOY, A. G., Institute of High Temperatures

[Abstract] A study is made of the thermal expansion of vacuum-melted tantalum and the tantalum-tungsten alloy TV-10 in the 1146-2288 K temperature range. The specimens studied were cylindrical rods 9 mm in diameter and 70 mm long. Experiments were performed in a vacuum of at least $5 \cdot 10^{-6}$ mm Hg. Two specimens of each material were studied. Before the beginning of the experiments,

the specimens were annealed in a vacuum in the experimental installation at about 2000°C for 1-1/2 hours. The experimental data are presented in tabular and graphic form, processed by the method of least squares, producing approximating equations for the mean temperature coefficient of linear expansion of these materials. The results are compared with data from the literature. References 23: 11 Russian, 12 Western.

USSR

UDC 532.529.6:538

HYDRODYNAMICS OF DISPERSED SYSTEMS INTERACTING WITH AN ELECTROMAGNETIC FIELD

Moscow MEKHANIKA ZHIDKOSTI I GAZA in Russian No 3, May/Jun 77 pp 59-70 manuscript received 2 Aug 76

GOGOSOV, V. V., NALETOVA, V. A., and SHAPOSHNIKOVA, G. A.

[Abstract] A system of equations is derived, describing the behavior of magnetized or polarized dispersed media in electromagnetic fields in the diffusion approximation. It is assumed that the medium consists of several phases and components, each of which is magnetized or polarized according to its own nature and has its own distinct temperature. A formula is derived for the forces applied to such a medium by an electromagnetic field, including components related to the nonequilibrium nature of the process. The method of the thermodynamics of irreversible processes is used to derive equations for the diffusion flow, heat flux, and equations for the rate of change of mass of an arbitrary phase, entropy of an arbitrary phase, as well as an equation for the rate of change of volumetric concentration of the phase. The methods suggested can produce equations for the change in volumetric concentrations of phases. References 18 (Russian).

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