

Chronicle

METAL-VAPOR LASERS AND THEIR APPLICATIONS

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The title of this chronicle repeats the title of the traditional Russian symposium that was held on September 22–26, 1996 at “Limanchik” recreation facility of Rostov-on-Don State University (RSU) near Novorossiisk. The program of the symposium included 80 papers the majority of which were successfully presented at the symposium.

Large group of the papers have been presented from the RSU – the organizer of the symposium. The paper “*Pulsed cathaphoretic metal-vapor lasers*” by E.L. Latush, G.D. Chebotarev, and A.V. Vasil’chenko has been reported by E.L. Latush. In his presentation Dr. Latush placed special value on the advantages of the cathaphoretic metal-vapor lasers (MVL) operated in a cw mode as well underlined certain peculiarities in the pulsed mode of their operation. Some properties of the He–Cd and He–Sr lasers have also been discussed in the paper together with the requirements to the so called white-light laser.

The next two papers were devoted to MVLs in a hollow-cathode electric discharge (HCD). Thus, I.G. Ivanov and A.Yu. Pimonov have presented a description of a pulsed helium–krypton–mercury laser in a HCD. The design of the active element in their laser has been earlier patented. In their experiments with this laser they have obtained the laser emission at 0.4694, 0.615, and 0.7945 micrometer wavelengths. G.A. Kalinchenko, I.G. Ivanov, A.G. Kour, V.L. Sukhorukov, and M.F. Sem have presented (G.A. Kalinchenko – presenter) the study of a cw HCD cadmium-vapor laser. In this study they have investigated the laser pump mechanisms. They managed to achieve lasing at three wavelengths with approximately 110 to 120 mW power each.

The papers “*Technique of optimal scaling of the recombination lasers*” by G.F. Chebotarev, E.L. Latush, R.Yu. Sotnikov and “*Monte-Carlo method in application to calculate characteristics of the laser active media*” by A.A. Abramov and G.N. Tolmachev dealt with the theoretical analysis of the processes occurring the MVLs. Drs. Abramov and Tolmachev made use of the Monte-Carlo method to model the collisional processes in the cathode drop and negative glow (NG) zones of a glow discharge. They have tested the method by comparing the calculated results on electron drift velocities, frequency of ionization and time of the discharge formation with the experimentally observed in a wide range of the E/p ratio values. They have also presented a comparative analysis of the NG-plasma parameters calculated for the case of injecting a monoenergetic electron beam into the NG zone from the cathode drop zone (the approach widely used in modeling) and those calculated using actual electron energy-distribution that is normally being formed in the cathode drop region of the discharge.

In the overview “*Mechanisms limiting the output power and the limiting characteristics of lasers on self-limiting transitions*” P.A. Bokhan (Semiconductor Physics Institute SB RAS, Novosibirsk) has analyzed the advances in copper-vapor lasers. In his opinion the pulse repetition frequency in these lasers is limited by a high density of electrons in the discharge during the prepulse period and not by that of particles in metastable states. This presentation initiated a vivid discussion and many questions have been put to the author.

On the same day P.A. Bokhan and D.E. Zakrevskii have presented the paper “*New method for determining the frequency capabilities of metal-vapor lasers*” with new experimental results obtained.

A series of papers have been presented by A.A. Isaev, Physical Institute, RAS, Moscow on the studies that were partially conducted in cooperation with scientists from St. Andrews University, Great Britain. Thus in a joint paper “*Electrical and mass-spectrometric properties of a hybrid and bromide copper-vapor lasers*” by D. Jones, K.I. Zemskov, A.A. Isaev, C. Little, G.G. Petrash, and C. White the authors have presented an intercomparison between the two types of copper-vapor laser. In the paper “*Hybrid laser: second harmonic generation*” these same authors reported on a high efficiency of the frequency conversion (25%) achieved in this laser. In the paper “*Effects of adding electronegative gases into the metal-vapor plasma*” by K.I. Zemskov, A.A. Isaev, and G.G. Petrash, from Ph.I., RAS, the authors presented the data showing that adding hydrogen into the gas mixture results in a delay of the leading edge of the discharge current and in an increase of the laser pulse amplitude, thus improving the performance characteristics of the laser.

At the poster session on that day the participants paid attention to the presentations: “*Time distributions of the luminescence on transitions of cadmium in a helium-cadmium medium excited by the nuclear fission fragments*” by E.D. Poletaev and Yu.A. Dyuzhev from the Physical-Energetic Institute, Obninsk; “*Optimization of the excitation conditions in active media of metal-vapor*” by Yu.P. Polunin, A.N. Soldatov, A.S. Shumeiko, and N.A. Yudin from Tomsk State University; “*Use of copper-vapor laser in oncology*” by V.A. Evtushenko, A.N. Soldatov, O.V. Cheremisina; “*Calculating the excitation kinetics in an MVL under conditions of controlled ionization*” by A.N. Soldatov and L.N. Chausova; “*Pulse-periodic discharge and parameters of electric circuitries to excite the metal-vapor lasing media*” by A.A. Isaev from the Ph.I., RAS; “*Experimental investigations of the output characteristics of lasers with low-inductance cells and fast voltage front*” by P.A. Bokhan and D.E. Zakrevskii; “*Small-size He–Se⁺ laser (430.5 nm) with high specific characteristics of the output emission*” by G.D. Chebotarev, E.L. Latush, and M.F. Sem.

The first paper presented after the break was that by V.V. Buchanov, M.A. Kazaryan, E.I. Molodykh, and V.A. Shcheglov from Ph.I., RAS on “*Methods to achieve cw lasing in a fast plasma flow*”. The topic discussed in this paper is one of the very urgent ones, however, the method proposed has very many questions to be addressed.

In the paper by Yu.B. Alferov, from Ph.E.I., Obninsk “*Possibility of creating a high-power nuclear-pumped mercury dibromide laser*” a model is constructed of a laser on the (B–X) transition of the HgBr molecule (502 nm wavelength) and mechanisms have been studied of exciting the lasing process in the medium of Ne–Xe–Hg–Br₂. Duration of a nuclear pump pulse was taken in this model to be 5 microseconds. The highest output parameters are achieved at the pump energy deposition of 1 to 10 kW/cm³ in a mixture that contains 90% of He, about 10% of Xe, and

0.05 to 0.2% of HgBr_2 at the buffer gas pressure of 2 to 5 atm. The lasing efficiency in this laser may reach the values of 1 to 1.5% and the lasing threshold being 0.7 to 0.8 kW/cm³.

M.A. Kazaryan, from Ph.I., RAS has delivered a paper "*Multichannel laser system for projecting the dynamic images*" in which he also made a review of the modern state-of-the-art in the applied studies of optical systems with amplification of brightness.

On the next day the first paper was presented by V.E. Privalov from the Baltic Technical State University, St Petersburg on "*Metal vapor lasers and the molecular iodine*" where he has analyzed the metrological and ecological aspects of that type of studies. The metal-vapor lasers frequency stabilized by the absorption by iodine may, if available, essentially increase the number of reference frequencies in the visible range. Use of copper-vapor laser-based lidars would make it possible to remotely detect the iodine and identify its isotopic composition thus enabling the assessment of the radioactivity of the objects sounded.

In the paper "*New capabilities of a source for pumping the open discharge gas lasers*" by A.R. Sorokin from the Semiconductor Physics Institute, SB RAS, Novosibirsk the author summarized his studies carried out since 1985 till 1995, that were published in Zh. Tekh. Fiz. and Pis'ma v Zh. Tekh. Fiz.

In the paper "*Numerical modeling and experimental study of the pulsed gas discharge and lasing at high pulse repetition frequencies*" by P.A. Bokhan, D.E. Zakrevskii, and A.Yu. Manakov has discussed the operation of a lead-vapor laser that uses pump pulse compression.

S.V. Arlantsev from the "Granat" EDB, Moscow – the author of the paper "*Manganese-vapor lasers pumped with a kV-electron beam: numerical modeling, comparison with the experiment, and potentialities*" has discussed the operation of a laser on self-terminating transitions in manganese atoms. The electron beam used in this laser is being obtained inside the working volume (for example, open discharge). The lasing efficiency may reach 10%.

The paper "*New possibilities of obtaining VUV-laser emission at the charge exchange reactions involving the noble gas ions and alkali metals*" presented by C.A. Ter-Avetisyan, G.T. Nersisyan, and V.O. Papanyan from the Institute for Physical Research of the Armenian Academy of Sciences discusses the possibilities of creating lasers capable of emitting in the vacuum ultraviolet region by using the reactions of charge exchange between the neon ions and rubidium atoms.

Then the discussions of the conference proceeded at the poster session where the following papers have been presented: "*On the mechanism of pumping the D-P transitions at 442 nm wavelength in a cataphoretic He-Cd⁺-laser*" by N.V. Brudastykh and I.G. Ivanov; "*VUV afterglow in alkali metal vapor and measuring lifetimes of some excited states of ions*" by C.A. Ter-Avetisyan and V.O. Papanyan; "*Applications of the laser spectroscopy*" by G.T. Nersisyan and V.O. Papanyan; "*Investigation of the track spatiotemporal evolution in a mixture of helium and metal vapor*" by A.P. Budnik, I.V. Dobrovol'skaya, and O.N. Katsuro from the Ph.E.I., Obninsk.

The paper "*On the creation of a laser system for gadolinium isotopes separation*" by A.I. Mashkunov has been presented as an extra-program paper.

After the break V.V. Zubov and N.A. Lyabin have presented their paper "*Recent advances in the development of commercially manufactured metal-vapor lasers*" where the

authors have given the table of specifications of the commercially available active elements "Kulon" and "Kristall".

A.N. Soldatov from Tomsk State University has then presented the paper "*New metal-vapor-based laser systems and their applications*" in which he told about the development of the metal-vapor lasers and their use in medicine and ecology.

The paper by G.S. Evtushenko, M.Yu. Kataev, and V.M. Klimkin from the Institute of Atmospheric Optics, SB RAS, Tomsk "*Detection of metal atoms in metastable states in the upper atmosphere with the use of MVLS*" was devoted to detection of chemical elements in the atmosphere using radiation of metal-vapor lasers.

The paper "*Asymmetry in optical excitation of the copper atom resonance states*" presented by G.S. Evtushenko on behalf of V.M. Klimkin and V.G. Sokovikov – the authors of this paper discusses some new experimental data on optical pumping of the copper atom working levels.

A.V. Ivanov presented the paper "*Photodynamic therapy of tumors with metal-vapor lasers*" by A.V. Ivanov, M.A. Kazaryan, Yu.A. Kuvshinov, and B.A. Poddubnyi from the N.N. Blokhin Oncological Center and Ph.I., RAS, Moscow in which they discussed a wide scope of problems, including the most effective, in therapy, laser wavelengths.

In the paper by N.A. Yudin "*Laser installation for dermatology*" the author has discussed the therapeutic devices based on the copper-vapor and CuBr-vapor lasers.

The last day discussion started with the presentation by A.A. Isaev from Ph.I., RAS "*Metal-vapor lasers and submicron technologies*" that discussed the use of copper-vapor and CuBr-vapor laser radiation of the fundamental frequencies and their second harmonics in photolithography.

The paper by V.M. Zharikov, V.V. Zubov and L.L. Betina from the SSPE "ISTOK" "*Use of copper-vapor lasers in the technology of manufacturing electronic components*" presented information on the use of "Karavella" "Klyon", and "Karelia" lasers to manufacture masks and fine working of films. The results have been shown on working the parts made from steel, molybdenum, tungsten, copper, aluminum, niobium, platinum, and gold. The surface quality on roughness parameter achieved was not worse than that when using the electro-erosion technique.

The paper "*Modified active element "Kulon" for lasers on copper (10 to 14 W) and gold (1 to 2W) vapor for applications in medicine, laser microscopy, and electronics production technologies*" has been presented by V.V. Zubov, M.A. Lesnoi, and A.D. Chursin from SSPE "ISTOK". The presenter Chursin A.D. has discussed the performance characteristics of the active element when filled with various mixtures and compared them with those of an English analog, by demonstrating the table of specifications.

In the paper by A.I. Moshkunov and V.A. Shutov ("Altek", Moscow) "*Power supply and control system for a multichannel laser system*" the information was presented about a high-power laser system based on "Kristall" active elements.

The closing discussion of the symposium has been started by V.S. Aleinikov (SSPE "ISTOK") and then continued by P.A. Bokhan, A.N. Soldatov, and V.E. Privalov. In the discussion the participants have formulated some scientific and technological suggestions that concerned the place of gas lasers and prospects of their use in modern technologies. Finally, it was announced that the next symposium would be held in Tomsk after the next regular ILPAM in September 1998.