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***PERSONALIA***

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# Zhores Ivanovich Alferov (on his seventieth birthday)

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Academician Zh I Alferov, full member of the Russian Academy of Sciences, an outstanding physicist and scientific organizer, director of the A F Ioffe Physical-Technical Institute, celebrated his 70th birthday on March 15, 2000.

Zh I Alferov was born in the city of Vitebsk. His father I K Alferov, who had participated in the October revolution and commanded a regiment during the Civil War that followed; in later life, he occupied top positions in the pulp and paper industry. Marx Alferov, Zh I Alferov's elder brother, joined the army as a volunteer at the outbreak of war in June 1941 when he was 17. He experienced all the stresses and strains of war during the Battle of Stalingrad and was killed in the Korsun'–Shevchenko operation in 1944. Zh I Alferov was first educated at school in the city of Minsk which he left as a gold medal winner in 1947 to pursue further studies at the V I Ul'yanov Electrotechnical Institute, Leningrad (LETI), from which he also graduated with first class honours.

His scientific creative potential was highly appreciated by V M Tuchkevich who invited Zh I Alferov to work in his laboratory at the famous Physical-Technical Institute (PTI), Leningrad, in 1953. Zh I Alferov made an important contribution to the development of the first Soviet transistors, photodiodes, and power germanium rectifiers. His work in these areas demonstrated the distinctive qualities which characterize his scientific activities at large: a deep understanding of the physical nature of the processes under study and a remarkable gift for applying the results of research to the construction of new devices and the resolution of concrete scientific, technological, and industrial problems.

In 1962, Zh I Alferov and a small group of his co-workers set to studying semiconducting heterostructures. Noteworthily, at that time many experts in semiconductor physics strongly doubted that this was a path in the right direction. Only few believed in the possibility of obtaining an ideal heterojunction with an interface free from defects in the crystal lattice. In striving for a solution, Zh I Alferov displayed remarkable scientific intuition and profound knowledge of physical processes. In 1967, the team led by Zh I Alferov succeeded in creating an almost ideal heterojunction by liquid-phase epitaxy. The central issue of their strenuous efforts was the discovery of a GaAs – AlGaAs system in which the constituent components exhibited an excellent correlation between lattice constants and thermal expansion coefficients. Successful simultaneous studies on electrical and optical properties of heterostructures also brought interesting results. Specifically, the researchers predicted and confirmed the superinjection effect. In other words, it was shown that the density of carriers injected into the narrow-bandgap semiconducting layer of a heterostructure turned out to be higher than the equilibrium density in the broad-bandgap layer functioning as an emitter. In addition, two other effects were first predicted and then discovered. The first was electronic confinement in heterostructures related to a change in the width of the bandgap and ensuring localization of carriers in the narrow-bandgap semiconducting layer. The second effect of optical confinement arises from the difference between refraction coefficients of the layers and allows for the creation of waveguide localization of electromagnetic waves. These findings opened new prospects for effective control of charge carriers and light fluxes.

Zhores Ivanovich Alferov

Taken together, the discovery of ideal heterojunctions, the development of technology for their fabrication, and the investigation of their physical properties by Zh I Alferov provided a solid foundation for the creation of a wide range of new semiconductor devices. In the space of only a few years (late 1960s – early 1970s), the laboratory headed by

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Zh I Alferov constructed heterolasers with a low threshold current density and realized, for the first time, continuous wave regime of them at room temperature. Other research and development projects of the laboratory included distributed-feedback lasers, highly effective light-emitting diodes, photodiodes, phototransistors, thyristors, and solar cells.

At the beginning of the seventies, Zh I Alferov and his collaborators formulated the principles of creation of 'ideal' heterostructures using multi-component (fourfold) solid solutions of $A^3B^5$ (e.g. InGaAsP heterostructures). This allowed the heterolaser generation wavelength to be extended to both infrared and visible wavelength regions. It is noteworthy that lasers of this type are now extensively used in optoelectronic devices for optical fibre communication systems. As early as 1970, Zh I Alferov and his team constructed the first high-performance photoelectric devices for the conversion of concentrated solar radiation. These works provided a basis for new developments in solar energetics. Photovoltaic systems of this type proved very effective and reliable. Suffice it to say that they were installed on the 'Mir' space station and still supply its power needs.

The latest important achievement of Zh I Alferov and his colleagues is the development of technology for growing heterostructures with so-called quantum dots, i.e. nanoscale semiconducting clusters 'sealed' in the bulk of another semiconductor material. Due to their small size, the crystal lattice of these clusters is ideally compatible with the matrix lattice despite the difference of lattice constants. The energy spectrum of such composite structures comprising a few thousands of atoms resembles that of an individual atom. These structures have been used to construct lasers with an unusually high thermostability promising a reduction of threshold currents by an order of magnitude compared with modern quantum well lasers. These works by Zh I Alferov laid the foundation of an essentially new field of electronics based on the use of heterostructures with a broad spectrum of practical applications currently known as 'band engineering'.

All these advances are underlain by the particular enthusiasm and keenness for innovative research peculiar to Zh I Alferov which helped him to assemble a highly efficient cast of physicists and engineers.

Zh I Alferov's works earned him a high world-wide reputation. In 1972, he and a group of his co-workers were awarded the Lenin Prize for ''Fundamental studies of heterojunctions in semiconductors and the development of new devices based on them''. In 1984, he received the State Prize of the USSR for a study on ''Periodic heterostructures of multicomponent (fourfold) solid solutions of $A^3B^5$ semiconductors''. Zh I Alferov has received several state honours, the very first one having been given to him in 1959 for the creation of semiconductor devices for nuclear submarines. In 1972, Zh I Alferov was elected a corresponding member of the USSR Academy of Sciences. He became a full member in 1979.

The outstanding scientific achievements of Zh I Alferov won merited recognition from the physical communities of Europe, the United States, and Japan. He was awarded a number of prestigious international prizes and medals (including the Gold Medal of the Franklin Institute, USA, in 1971). Zh I Alferov is a member of several foreign academies and scientific societies.

Zh I Alferov shows great and abiding interest in the education of young scientists. In 1973, he and V M Tuchkevich organized the Chair of Optoelectronics at LETI (now St Petersburg State Electrotechnical University). Since then, many graduates of this Chair have been enrolled at PTI and work successfully in its laboratories. Later, similar, PTI-based chairs were organized at the Leningrad Polytechnical Institute (now St Petersburg State Technical University). In 1988, they were amalgamated to form the Physical-Technical Faculty of this institute, and Zh I Alferov took over the duties of its Dean. The next step towards the improvement of the selection and education of young physicists was the opening of the PTI-based Physical-Technical Lyceum to which Zh I Alferov also gives immense encouragement. The academic curricula of both the Physical-Technical Faculty and the lyceum have been developed in such a way as to be in close unity with research projects underway in the PTI laboratories. The strenuous efforts of Zh I Alferov culminated in the specially built premises to which the lyceum and the above PTI-based chair, faculty, and also educational laboratories moved in 1999. Their comfortable and convenient accommodation in one block considerably extends the possibilities of continuous education with a view of widening primary students' training into the university education of research scientists. These new educational facilities are a legitimate object of Zh I Alferov's pride.

In addition to his work at PTI, Zh I Alferov is engaged in many and varied activities outside the institute as an organizer of research and a planner of scientific programmes. He is Vice-President of the Russian Academy of Sciences, Chairman of the Presidium of the St Petersburg Research Center of the Academy, a member of the Bureau of the Division of General Physics and Astronomy, RAS, and Editor-in-Chief of *Pis'ma Zh. Tekh. Fiz.*

Zh I Alferov, with his eminent public and political temperament, is the bearer of a long-standing PTI tradition which goes back to the directorship of A F Ioffe: being a Deputy of the State Duma (a member of parliament), he successfully combines scientific and public activities.

With such a range and quantity of work, one would think Zh I Alferov has no moments for recreation. Yet, he finds time to enjoy the social and cultural life. Zh I Alferov is a captivating conversationalist and story-teller. Meeting all sorts of people representing different specialities and living in different cities and countries, he tells about these encounters with true artistic skill. He is also an attentive listener always ready to help those in need of his advice and support.

We heartily wish Zhores Ivanovich Alferov, on his seventieth birthday, good health and many valuable contributions to the benefit of science.

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