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PERSONALIA

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In memory of Zhores Ivanovich Alferov

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Zhores Ivanovich Alferov, the outstanding Soviet and Russian scientist, passed away on 1 March 2019. Zhores Ivanovich was a first-rate specialist in the field of semiconductor physics and semiconductor optoelectronics, the author of more than 500 scientific papers, over 50 inventions, and several books, a laureate of the Lenin Prize and two State Prizes, the 2000 Nobel Prize winner in physics, vice-president of the Russian Academy of Sciences (in the period from 1990 to 2017), a foreign member of academies of sciences of many countries, a well-known public and political figure, a member of the State Duma, the oldest employee at PhysTech (Ioffe Physical and Technical Institute), who devoted 50 years of his life to the institute, its director from 1987 to 2003, the hardest period for our science, and founder and rector of the Academic University.

Zhores Ivanovich Alferov was born on 15 March 1930 in Belarus in the town of Vitebsk to a family of a St. George cavalier, engineer, and 'red director', I K Alferov. Before World War II, following different assignments of his father, the family moved a great deal about the country and returned to Minsk after the war. Zhores felt love for his small motherland all his life. After graduating with a Gold Medal from secondary school in Minsk, he entered the Electronic Engineering Department of the V I Ulyanov (Lenin) Leningrad Electrotechnical Institute (LETI), from which he graduated with the highest distinction in 1952, and from 1953 he worked at the Physical and Technical Institute (PTI) of the USSR Academy of Sciences (later Ioffe PTI RAS) up to 2006. In 2003, he resigned as director, and in 2006 as research supervisor of the institute.

All his life, Zhores Ivanovich was engaged in semiconductor physics. His first important scientific and engineering achievements go back to the time of his work in the laboratory headed by V M Tuchkevich. In 1953, a team with Alferov's participation created Soviet transistors with p–n junctions. In five years, the junior researcher Alferov took part in performing a task of the Government of creating special semiconductor devices for submarines, for which he received his first order, the Badge of Honor.

Having defended his Candidate thesis in 1961, Alferov soon turned to the subject that became the main goal of his scientific life. He proceeded from the general idea that the performance capabilities of semiconductor devices with p–n junctions would be widened drastically if they were manufactured using contacts of materials with different band structures. Zh I Alferov's attention was attracted by the possibility of implementing semiconductor heterostructures with ideal defectless heterojunctions based on the direct band compounds $A^{III}B^{V}$.

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Zhores Ivanovich Alferov
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In 1963, Zh I Alferov and R F Kazarinov obtained their first patent, in which they formulated the idea of creating a semiconductor double heterojunction laser diode. In 1970, for the first time in the world, a laser diode was created on a heterostructure in the AlAs–GaAs system, which operated in cw mode at room temperature. The results of these studies, which were ahead of their time, were included in Zh I Alferov's Doctor of Sci. thesis he defended in 1970. For this discovery, he received the same year the Stuart Ballantine medal from the Franklin Institute. In 1972, Zh I Alferov became a corresponding member and in 1979, at the age of 49, a full member of the USSR Academy of Sciences. All these years, he put great effort into development and industrial implementation of semiconductor devices based on $A^{III}B^{V}$ heterostructures. This resulted in the appearance of laser diodes operating in a broad spectral range (650–1500 μm), high-power AlGaAs lasers, high-voltage AlGaAs rectifiers, high-efficiency light-emitting diodes, photodetectors, and, of great importance, high-efficiency heterostructural photoelectric AlGaAs-based converters of solar radiation that proved indispensable for supplying power to space stations.

With the world-wide development of new epitaxial nanotechnologies, the first domestic systems for molecular beam epitaxy (MBE) and MOS hydride epitaxy appeared in Alferov's laboratory at PhysTech already in 1980. In 1987, under his leadership a record-breaking low-threshold hetero-

laser with a threshold current of 40 A cm^{-2} was designed and manufactured using the MBE technology. The laser used a separate-confinement double heterostructure AlGaAs with the active region based on a GaAs quantum well confined by a gradient waveguide superlattice. With this work he was many years ahead of similar studies abroad. An important continuation of this research was implemented in Zh I Alferov's laboratory, where the same MBE technology was used to create in 1994 the first semiconductor lasers based on self-organizing InAs quantum dots that became the subject of long-term intense studies in hundreds of laboratories around the world owing to their remarkable physical properties and prospects of practical applications. These studies stimulated the formation of a new field of optoelectronics — quantum nanophotonics — aimed at realizing optical systems for quantum calculations and quantum cryptography. In 2000, Zhores Alferov, together with Herbert Kroemer and Jack Kilby, was awarded the Nobel Prize in Physics for "fundamental works in the field of information and communication technologies" that changed radically the character of the modern world.

During the last decade and a half of Zh I Alferov's work at the Academic University, which was founded in 2002 on his initiative and whose permanent rector he had been since then, Zhores Ivanovich's main scientific interests lay in such important and topical fields as integration of optoelectronics on the basis of $A^{III}B^{V}$ nanoheterostructures with silicon microelectronics in unified epitaxial heterostructures and in the use of physical methods and approaches in biology and medicine.

Alferov's role in the life of our science and society goes far beyond his scientific achievements. First and foremost, we should mention his activity in the sphere of education and training of new generations of physicists and engineers — from school to postgraduate course. In 1973, he organized a base sub-faculty at his native LETI. The best theoreticians and experimentalists at PhysTech were involved in teaching optoelectronics. This sub-faculty is now one of the best in engineering physics in our country, and it can be proud of the successful scientific careers of its graduates. In 1988, Zh I Alferov organized the Physical and Technical Department at the Saint Petersburg Polytechnical Institute and became its dean. An important step was also the setting up of the basic Physical-Technical School (later renamed a lyceum) at PhysTech in 1987.

In 2002, the Academic Physics and Technology University (APTU) and then in 2004, the Saint Petersburg Center for Physics and Technology of the RAS (CPT) were founded. In 2009, APTU, CPT, and the Lyceum Physical-Technical School joined to form a unified institution — the Saint Petersburg Academic University — Nanotechnology Research and Education Center (REC) of RAS, with Zh I Alferov as its rector. He devoted much attention to making known scientific and cultural achievements to schoolchildren and students. A center for public lectures was organized on his initiative at the Academic University, where leading scientists, cultural figures, and well-known politicians were drawn.

Zh I Alferov's international authority was exceedingly high. He was member of several foreign academies and scientific societies, was an honorary doctor and professor of many foreign universities, and had numerous foreign awards — orders, medals, and prizes. His weighty authority in the world scientific community allowed Alferov to make invaluable contributions to establishing and strengthening international contacts to Russian scientists. He successfully organized a great number of international meetings. In 1993, together with his Japanese colleague and friend Leo Esaki, he organized the international symposium, Nanostructures: Physics and Technology, which was held annually — first in St. Petersburg and then in many other scientific centers in Russia and Belarus. In the framework of the scientific forum Science and Society organized by Alferov on the 300th anniversary of the Northern Capital, the first meeting of Nobel Prize winners "Science and Progress of Mankind" was held in St. Petersburg. Twenty Nobel Prize winners in physics, chemistry, physiology, medicine, and economics attended the meeting. From 2008, the Nobel meetings became annual. Owing to his world celebrity and scientific authority, Zhores Ivanovich was elected co-chairman of the Scientific Advisory Council of the Skolkovo Foundation.

The whole activity of Zhores Ivanovich Alferov as a long-standing member of the State Duma was aimed at supporting Russian Science and the Russian Academy of Sciences.

Zhores Ivanovich Alferov's death is an irreplaceable loss for science in Russia and the world.

A L Aseev, D A Varshalovich, E P Velikhov, I V Grekhov, Yu V Gulyaev, A E Zhukov, S V Ivanov, A A Kaplyanskii, P S Kop'ev, G Ya Krasnikov, P A Suris, V E Fortov