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Zhores Ivanovich Alferov (on his 80th birthday)

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Academician Zhores Ivanovich Alferov, outstanding Russian physicist and science manager, Nobel Prize winner, and Rector at Saint Petersburg Academic University–Nanotechnology Research and Education Center of the Russian Academy of Sciences, celebrated his 80th birthday on March 15, 2010.

Zh I Alferov was born in Vitebsk. His father, Ivan Karpovich Alferov, fought in WWI, commanded a regiment during the Civil War, and later became one of the top managers of the cellulose and paper industry in the USSR. The family moved often from town to town and Zhores Alferov attended schools in Novosibirsk, Barnaul, Syasstroi, Turinsk, and Minsk. His mother, Anna Vladimirovna, managed the life of the family, was socially active, and was elected as a delegate to the All-USSR Gathering of Socially Active Wives. His elder brother, 17-year-old Marx Alferov, volunteered to go to the front, fought in the defense of Stalingrad, and was killed in 1944 during the Korsun–Shevchenkov operation.

By the time he graduated from high school, Zh I Alferov had become greatly interested in electronics, a new field of science and engineering. In 1947, he graduated high school in Minsk being awarded a Gold Medal and enrolled first in the Department of Electronic Devices of the V M Molotov Moscow Power Engineering Institute. After two months at the MPEI, he was transferred to the Power Engineering Department of the I V Stalin Belarussian Polytechnical Institute, but after a year there was transferred again to the second course at the Electronic Engineering Department of the V I Ulyanov (Lenin) Leningrad Electrotechnical Institute (LETI). In 1953, after defending his diploma thesis devoted to the fabrication of bismuth telluride films and studies of their photoconductivity and on graduating from LETI *summa cum laude*, he immediately started his work as a researcher at the Ioffe Physical-Technical Institute (FizTekh in *Russ. abbr.*) in Leningrad. He had thus found his place in life and his subsequent creative and productive path through science can be regarded as a pattern of concentration on the most important goals.

From his first days at FizTekh (where he ultimately became Director in 1987 and occupied this position until 2003), Zh I Alferov took active part in the study of germanium diodes and triodes (transistors) with p–n junctions; this led to the production of the first planar junction transistors in the USSR. These early works highlighted what became his trademark approach to research in general: the drive to profoundly penetrate the physics of the processes under study and the brilliant ability to apply the obtained scientific knowledge to the creation of new devices and solving concrete technological problems. Zh I Alferov then completed a set of projects on developing and investigating high-power germanium and silicon rectifiers which proved important in the program of development of Soviet atomic submarines. In 1959, this work, which set the foundation for power semiconductor electronics in the USSR, brought the young scientist the Order of Honor.

Zhores Ivanovich Alferov

In 1962, Zh I Alferov and a group of coworkers started a research project aimed at creating efficient semiconductor lasers. Zh I Alferov put forward a very new approach to radically improving the characteristics of then existing lasers based on semiconductor homo-p–n structures: using semiconductor heterojunctions, i.e., contacts between semiconducting materials with different band gaps. Zh I Alferov and his team were able to demonstrate the feasibility of superinjection in a heterojunction, i.e., of producing in a narrow-band material the concentrations of nonequilibrium charge carriers higher than the equilibrium concentration possible in a broad-band material. To make use of the superinjection effect, Zh I Alferov proposed a double heterostructure (DH) in which the regions of recombination and emission of light are localized in the middle narrow-band layer, while population inversion is achieved through injection. The implementation of these ideas resulted in an increase by orders of magnitude of the main parameters and characteristics of

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semiconductor lasers, and later led to a true revolution in optoelectronics. In 1967, Zh I Alferov and coworkers demonstrated how it was possible to create GaAs/AlGaAs heterostructures with properties closely approaching those of the ideal model. The first DHS lasers with record-low generation thresholds were obtained as early as 1969, making it possible for the first time in the world to produce continuous generation at room temperature. In 1971, Alferov was awarded the Franklin Institute (USA) Gold Medal for this work, and in 1972 Alferov himself and the team he headed won the Lenin Prize.

Zh I Alferov's research in semiconductor heterojunctions soon grew larger than the field of laser physics and generated a number of new academic and engineering branches. One of the impressive examples was the creation of efficient solar photoelements based on heterostructures. Since AlGaAs/GaAs-based photoelements proved, in addition to other benefits, more radiation-resistant than silicon-based ones, they rapidly found applications in space technologies. One of the solar batteries installed aboard the space station MIR as far back as 1986 worked there the entire life of the station without a significant drop in power output. Owing to the energy barriers for electrons and holes in a system of two heterojunctions, the double heterostructures discovered by Zh I Alferov became immediate predecessors of the structures in which the dimensional quantization effects show themselves; these structures now constitute the key lasing medium of many semiconductor devices. Without them, the fastest modern transistors could not have been created — transistors with high-electron mobility in a two-dimensional conducting channel, resonance tunnel diodes, and quantum cascade lasers. The contribution of Zh I Alferov to science was celebrated by conferring on him in 2000 the Nobel Prize in Physics "for developing semiconductor heterostructures used in high-speed- and opto-electronics".

Further theoretical studies and progress in epitaxial technologies led to the emergence of quantum dots — a new type of heterostructures which implement the limiting case of dimensional quantization, namely, the motion of charge carriers limited in all three directions within a volume of space comparable to the exciton radius (about 10 nm). The work on quantum dots was initiated in this country in Alferov's laboratory at the beginning of the 1990s. The world's first laser based on quantum dots was created already in 1993. Further research led to the creation of another first — a low-threshold quantum-dot laser — and to a demonstration of continuous-mode generation in this system, at the same time substantially expanding the spectral range achievable in laser structures on a specific type of the substrate. In 2001, the research team headed by Zh I Alferov was awarded the RF State Prize for the "Fundamental studies of the formation processes and of the properties of heterostructures with quantum dots and for creating lasers based on them".

In 1972, the USSR Academy of Sciences elected Zh I Alferov a Corresponding Member, and in 1979 a Full Member. At the moment, he is the Vice President of the Russian Academy of Sciences (RAS), Chairman of the Presidium of the Saint Petersburg Scientific Center of the RAS, and head of the nanotechnologies section of the Division of Nanotechnologies and Information Technologies of the RAS. The international rating of Zh I Alferov is remarkably high. He has been elected a member of several foreign academies and scientific societies and received honoris cause and professorships at many universities. Zh I Alferov's multifaceted activities have brought him numerous orders and medals in this country and abroad.

In our science and in our society, Zh I Alferov plays a role that far exceeds the bounds of his scientific achievement. First of all, we wish to emphasize his work in educating and training new generations of physicists and engineers. Zh I Alferov invariably propagated the idea that the responsibility of a scientist lies not only in research but also in his/her educational contribution. In 1973, he organized at LETI the first basic chair in the USSR. The best scientists of FizTekh were drawn into teaching at the Chair of Optoelectronics. This chair very soon became one of the best in engineering physics in this country. Among its former students we find three Corresponding Members of the RAS. In 1988, Zh I Alferov organized the Physical-Technical Department at the Saint Petersburg Polytechnical Institute and became its dean. His next important step in improving the quality of training of physicists was the setting up in 1987 of the Physical-Technical School at the Ioffe Institute (later renamed Lyceum 'Physical-Technical School'), in whose life Zh I Alferov still continues to take a most active part. In 2002, he organized the Academic Physics and Technology University (APTU in *Russ. abbr.*) — the first higher-education entity incorporated into the Russian Academy of Sciences — and then in 2004, the Saint Petersburg Scientific and Educational Center for Physics and Technology of the RAS (SEC). In 2009, APTU, SEC, and the Lyceum were merged, on Alferov's initiative, into a unified Saint Petersburg Academic University – Nanotechnology Research and Education Center of the RAS, with Zhores Ivanovich Alferov as its Rector. The academic university essentially continues the tradition of triune 'composition' — academy of sciences, academic university, and academic gymnasium — founded by Tzar Peter I when he decided to create the Saint Petersburg Academy of Sciences. The new University is housed in a modern architectural complex complying with the highest international standards for laboratory equipment and the organization of the research and education processes.

Zh I Alferov's charitable activities are also a model for implementing lofty social ideals and an active civic attitude. In 2001, he launched the Foundation for Support of Education and Science (The Alferov Foundation) in order to contribute to the advancement of science and education in Russia; he donated to this foundation a considerable part of his Nobel Prize award. More than 200 high-school pupils, students, and postgraduates receive scholarships from the Alferov Foundation. The foundation also set up a special Marx Alferov scholarship for pupils living in areas connected with the life and military career of Marx Alferov. The foundation confers annually a Prize and Gold Medal for the best research work in the natural sciences done by a young researcher. A program of lifelong financial support to widows of full members and corresponding members of the RAS who worked in Saint Petersburg started operating from the very beginning of activities of the Alferov Foundation.

Zh I Alferov carries a heavy load of duties as a Member of the State Duma — the Parliament of the Russian Federation. Despite his exceptionally busy schedule, he finds time for regular meetings and discussions with science and teaching activists, with the young generation, and with anyone who is not indifferent to the fate of the country and of its scientific potential.

On the occasion of Zhores Ivanovich Alferov's 80th birthday, we wish from the bottom of our hearts that he remain healthy and enjoy new important achievements for the good of science.

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