PERSONALIA

PACS number: **01.60. + q**

In memory of Viktor Sergeevich Vavilov

DOI: 10.1070/PU2000v043n02ABEH000735

Viktor Sergeevich Vavilov, a prominent scientist well known for his research in the field of semiconductor physics, one of the founders of the radiation physics of semiconductors died on January 25, 1999.

V S Vavilov was born on July 8, 1921 in Moscow, in the family of S I Vavilov, the outstanding physicist and President of the USSR Academy of Sciences. After finishing secondary school, V S Vavilov was called up for military service. He participated in the 1939 – 1940 Finnish campaign and in the Great Patriotic War in Leningrad during the blockade.

In 1949 V S Vavilov graduated from Leningrad University and then worked for two years as a research worker at the State Optical Institute, and from 1951 to 1999 at the P N Lebedev Physics Institute of the Russian Academy of Sciences (FIAN) as head of the scientific group in the Semiconductor Physics Laboratory. Simultaneously, from 1956 he was engaged in pedagogical work as professor and head of the Chair of Semiconductors at the Physics Department of the M V Lomonosov Moscow State University.

Semiconductor physics and engineering had become the main inspiration of V S Vavilov's life since he came to the semiconductor physics laboratory in 1954 and began his research work by active participation in the creation of first Soviet alloyed and diffused diodes and triodes on germanium and silicon.

V S Vavilov's main works were connected with the study of processes of interaction of electromagnetic radiation and high-energy charged particles with semiconductors, including radiation-induced ionization, the properties of nonequilibrium plasma, semiconductor luminescence, as well as the formation of radiation-induced defects, ion implantation and synthesis of semiconductor compounds using accelerated ions.

In the 1950s, V S Vavilov together with L S Smirnov, V M Patskevich and M V Chukichev performed experiments that made it possible to determine the energy of formation of a pair of charge carriers upon fast electron deceleration, absorption, and scattering of gamma-ray emission in germanium and silicon.

The data on the dependence of the energy of formation of pairs of carriers on the type and energy of ionizing particles laid the basis for the creation of semiconductor detectors; the impulse electron excitation later on became one of the methods to achieve the lasing regime in semiconductor lasers.

A considerable part of V S Vavilov's research work was devoted to optical processes and the photoelectric effect in semiconductors. An increase in the quantum yield of photoionization up to values exceeding unity was revealed by V S Vavilov and K I Britsyn in germanium and silicon and was used to develop the collisional ionization model.

Uspekhi Fizicheskikh Nauk **170** (2) 203 – 204 (2000)
Translated by M V Tsaplina

Viktor Sergeevich Vavilov
(08.07.1921 – 25.01.1999)

Among V S Vavilov's works referring to optical phenomena in semiconductors one should point out the experimental studies of the Keldysh – Franz effect in silicon which provided the first data on both the spectral dependence and the kinetics of this phenomenon.

A number of V S Vavilov's works were connected with the investigation of photoionization phenomena that led to the realization and implementation of Soviet silicon solar batteries for space applications. V S Vavilov, together with G N Galkin and V M Malovetskaya, was the first to suggest and apply the technique of anti-reflection coating for solar batteries which is widely used nowadays.

A large series of works by V S Vavilov and his co-workers were devoted to the study of the nature and stability of radiation-induced defects in germanium and then in silicon and other semiconductors. It should be noted that the studies of the energy spectrum of radiation-induced defects by the methods of analysis of spectra and kinetics of photoconductivity undertaken at FIAN by V S Vavilov and his postgraduate students A F Plotnikov, I P Akimchenko, and

V D Tkachev represented a new stage in the research on radiation-induced defects in semiconductors. The studies carried out at that time in many Soviet and foreign laboratories (France, USA, Japan) were a logical continuation of the research initiated at FIAN. The clarification of the interaction processes between defects and impurities allowed V S Vavilov together with his post-graduate student I V Kryukova and M V Chukichev to propose and apply the method for increasing the radiation stability of silicon through the introduction of a mobile lithium impurity. This method found significant practical applications in the USSR and other countries. At the present time, the method of introduction of radiation-defect 'annihilation centers', which was first used by V S Vavilov and his disciples, now seems to be a promising way of increasing the radiation stability of semiconductors.

The cycle of works on radiation-induced defects was continued by the studies of reactions in crystals stimulated by nonequilibrium mobile interstitial atoms and empty sites, i.e., vacancies. These works served as a basis for such promising and now popular methods of solid state electronics as ion and transmutation doping and 'laser' annealing.

The results of the studies listed above were summarized in the doctor's dissertation presented by V S Vavilov in 1961 and in the monograph *Effects of Radiation on Semiconductors* published in the USSR in 1963 and in the USA in 1965. Later, V S Vavilov paid special attention to the problems of radiative recombination under pulsed electron excitation, which led to the realization of the laser regime in some semiconductor $A^{II}B^{VI}$ crystals. Later, in addition to the studies of luminescence of strongly excited semiconductors, some other experiments were carried out (the determination of cross-sections of light absorption by free carriers; studies of the effect of nonequilibrium plasma upon optical parameters of the excited crystal). The results of these studies, as well as the investigation of impact recombination (Auger processes) undertaken by V S Vavilov, G N Galkin and the post-graduate student L M Blinov were ahead of analogous research abroad (Germany, Sweden). V S Vavilov with G N Galkin and M E Epifanov discovered the phenomenon of intense photon transport of nonequilibrium carriers in gallium arsenide.

The method of investigation of absorption and photoionization phenomena in the far infrared region, proposed by V S Vavilov and applied by him together with V N Murzin and V A Zayats for examination of excitons and nonequilibrium plasma in germanium at low temperatures made possible obtaining new data on the energy spectrum of excitons and their condensation in strongly excited semiconductors. After the experiments first conducted in FIAN, similar works were performed in other Soviet and foreign laboratories.

V S Vavilov was one of those who initiated research works on employing the properties of diamond and its application in electronics. V S Vavilov and his colleagues used the ion implantation method to produce stable semiconducting layers with hole and electron conductivity near the surface of insulating diamond crystals and to obtain silicon carbide layers on diamond. The results of these studies were ahead of those performed by foreign authors who conducted research in this direction, in particular, in the USA and England.

Layered metal – insulator – semiconductor and other structures can be used to memorize and read images and signals. The works done by A F Plotnikov and V E Shubnikov on V S Vavilov's initiative have demonstrated that InSb-based MIS structures exhibit properties that are promising for practical applications.

The book *Radiative Effects in Semiconductors and Semiconductor Devices*, written by V S Vavilov and N A Ukhin and devoted to the effects of radiation upon semiconducting materials and devices, the as well as V S Vavilov's monographs *Mechanisms of Production of Radiation-Induced Defects and Their Migration* (in co-authorship with A E Kiv and O R Niyazova) and *Electron and Optical Processes in Diamond* (in co-authorship with A A Gippius and E A Konorova) were met with great interest by specialists.

26 candidate dissertations were defended under the tutorship of V S Vavilov. Many of V S Vavilov's disciples, namely, L S Smirnov, A F Plotnikov, V D Tkachev, L K Vodop'yanov, G N Galkin, B N Mukashev, A E Kiv, A A Gippius, L M Blinov, A M Zaĭtsev, K I Britsyn, I V Kryukova, E V Shatkovskiĭ, K Kh Nusupov and others are doctors of science, and some of them at different times were and are now heads of research teams.

V S Vavilov conducted extensive scientific-organizational work as chairman of the section of ion implantation physics of the Scientific Council of the USSR Academy of Sciences, where he was engaged in the problem of "Physics and Chemistry of Semiconductors", and was Scientific Secretary of the P N Lebedev Gold Medal Committee of the Presidium of the USSR Academy of Sciences.

For his participation in the Great Patriotic War V S Vavilov was awarded five medals, in 1961 he received the Order of the Red Banner of Labor for his works on the application of semiconductors in space research and in 1970 — the Medal for Distinguished Labor. V S Vavilov was awarded the 1971 and 1988 USSR State Prizes for his works on semiconductor solar power engineering and semiconductor electronics and the 1986 Prize of the USSR Council of Ministers for work on the application of natural diamonds in electronics.

V S Vavilov's great erudition, experience, devotion to his work, loving kindness towards his colleagues, willingness to help people and tactful humor were features very attractive for the younger generation and his numerous friends and colleagues. Many physicists of the middle and older generation will remember the interesting meetings with V S Vavilov at conferences, scientific schools, seminars and in unconstrained domestic surroundings and during trips.

N G Basov, V L Ginzburg, A A Gippius,
V S Dneprovskiĭ, L V Keldysh, Yu V Kopaev,
V V Krasnopevtsev, O N Krokhin, V P Silin,
L S Smirnov, E L Feĭnberg, A P Shotov