

# Academician D.I.Vaisburd S.P. Bugaev

*is a graduate of Tomsk school  
of dielectrics physics*

In accordance with UNESCO policy, in autumn 2000, at the Millennium threshold, the whole world celebrates our anniversary - 100 years of studies beginning in Tomsk Polytechnic University, the oldest technical institution of higher education on a vast territory from the Urals to the Far East of Russia.

This anniversary year, significant and pleasant event for all of us has taken place. At the May session of the Russian Academy of Science General Meeting, Sergey Petrovich Bugaev a TPU graduate, the Director of the Institute of High Current Electronics of Siberian Branch of the Russian Academy of Sciences (IHCE SB RAS), was elected as a RAS academician. Another graduate of TPU has become an academician. Tomsk Polytechnic University is proud of its graduates - outstanding scientists and science organizers. If you come to the first floor of the TPU main building and look at a long series of portraits of outstanding polytechnicians, then your attention will be attracted by three portraits closely spaced. These are the portraits of academicians G.A.Mesyats, B.M.Kovalchuk and S.P.Bugaev. All of them began their scientific activities in one and the same laboratory, housed in the TPU 11-th building, in the Institute of Nuclear Physics at Tomsk Polytechnic University. Later on they together created and developed one and the same field of science and engineering, called «High Current Electronics» (or «Superpowerful Electronics»). But a bit later about this.

Since 1985 there has been the reconstruction («perestrojka») of the economy, political system and the development of democratic freedoms in this country. In this time interval, a lot of different academies in various areas of knowledge, science and engineering, mainly as social organizations, has been established. Now, their number exceeds 150. In the course of time in future some of them will probably take a worthy place among prestige academies of the world. But now in Russia only one Academy raises high above all of them. It is the Russian Academy of Sciences, that was founded by the emperor Peter the Great by his decree in 1724. The great scientists Euler, Bernoulli, Lomonosov were the first academicians.

To be elected to the RAS academician election is a multistage, long and very complex procedure. At first, a pretender is presented by the Scientific Council of academic institute. Then, as a result of a secret ballot voting, he is recommended by the general meeting of the Regional Branch, for example, Siberian Branch of RAS, then by the Science Field Branch, for example, Branch of General Physics and Astronomies of the RAS. And, finally, he should pass the General Meeting of the Russian Academy of Science, where the pretender is elected by only the academicians, by a secret ballot. The total number of the academicians is about 600 for all Russia. The academic rank is a life rank. Moreover, the academicians are very independent in their opinions and judgments. So, they elect

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only those people who are worthy of this honour. It is S.P.Bugaev who was conferred with this honorary rank of me academician.

Sergey Petrovich Bugaev was born in Leningrad on August 3, 1936. His father was a military man, and the family moved from one region to another. He finished school in Khabarovsk and went to enter TPU Radioengineering faculty. After graduating from the Radioengineering faculty, S.P.Bugaev joined me scientific group headed by G.A.Mesyats and forever connected his scientific activities with him. This group was included into the Department of high-voltage apparatuses of millimicrosecond engineering of the Research Institute of Nuclear Physics at TPU. The Department was headed by Grigorij Abramovich Vorobjev - a follower and co-worker of Aleksander Akimovich Vorobjev. So, from the very beginning of his scientific activities S.P.Bugaev was admitted to one of the most perspective scientific schools of Tomsk Polytechnic University - the dielectrics physics school. The establishing of the scientific school has begun since 1929, when one of the prominent physicist of XX century, professor P.S. Tartakovsky, arrived in Tomsk from Leningrad.

Tartakovsky Peter Savvich (1895-1910) is known first of all by the fact that he, independently and simultaneously with the English physicist P.J.Thomson, carried out the experiments on direct observation of electron diffraction on thin metal foils (Leningrad, 1926-1928). These experiment results were included into physics textbooks under the title «Thomson and Tartakovsky Experiments». This phenomenon underlies the modern quantum physics and philosophy. The results of the electron diffraction experiments influenced and continue to influence on the people outlook in the XX century. There is an interesting situation. On the one hand, the quantum theory, which arose in the late 1920s, became one of the most accurate and fruitful physical theories. It has brought a record number of practical results to the mankind. On the other hand, its predictions seem so strange that experiments on electron and foton diffraction have been carried out in new versions during more than 70 years. Their results constantly agree with the quantum theory but being extraordinary for human mentality they constantly amaze imagination of

researchers, since they were used to the macroscopic world.

Since autumn 1924 till March 1929, Tartakovsky was working in the Laboratory of the academician A.F.Ioffe by the State Physical and Technical Institute (Leningrad). Here P.S. Tartakovsky was deeply emerged in the creative atmosphere of developing quantum physics, discussed his results and ideas with A.F.Ioffe and Y.I.Frenkel, the prominent Leningrad scientists.

In the late 1920s, a network of Physical and Technical Institutes like Leningrad Phystekh (now, the Ioffe Physical and Technical Institute of the RAS in St.-Petersburg) was organized in the country on the initiative of A.F.Ioffe. The Ukrainian Physical and Technical Institute (UPTI) in Kharkov and Siberian Physical and Technical Institute (SPTI) in Tomsk (1928) were established. Ioffe offered Tartakovsky to go to Tomsk for some years and work there in SPTI, which, by the way, was organized by TPU (then Tomsk Technological Institute) and only later was transferred to Tomsk State University (TSU). Since 1929 Tartakovsky was the Head of both Electronic Phenomena Laboratory (in SPTI) and the Chair of Theoretical Physics Faculty of TSU.

In Tomsk, P.S. Tartakovsky began a new cycle of experiments devoted to studies of quantum properties of electrons. Tartakovsky invited a group of young physicists - graduates of the Physics and Mathematics Faculty (TSU), to this work. Among the graduates, Aleksander Akimovich Vorobjev, who, being a post-graduate student of P.S. Tartakovsky, carried out experiments on internal photoeffect in alkaline-halide crystals in strong electrical fields. They observed the photoconductivity, development collisional ionization and an electrical breakdown of a dielectric. It is amazing how much P.S. Tartakovsky with his followers could do only for 6 years. He devoted his final monography, which was published in 1940, to the internal photoeffect in dielectrics. It was translated into many foreign languages and up to now is quoted all over the world as a classical work on physics of electronic-hole processes in dielectrics.

In 1937 P.S. Tartakovsky returned to Leningrad from Tomsk and died in October 1940, at the age of 45. He was buried on the Bogoslov cemetery of St.-Petersburg.

The works of P.S. Tartakovsky, one of the founders of modern experimental quantum physics, and his followers formed the basis, from which the Tomsk scientific school of dielectrics physics came. The school was concentrated mainly in Tomsk Polytechnic University due to the activities of the outstanding organizer of science and higher education – A.A. Vorobjev.

Vorobjev Aleksander Akimovich (1909-1981) came to Tomsk Polytechnic University in 1940. At first, he worked as a professor, then as the head of the Chair of Physics Faculty and in 1944 he was appointed as the TPU Rector for 26 years, till 1970. He developed scientific researches with an immense energy and range.

The following scientific directions were intensively developed:

1. Physics of an electrical breakdown of dielectric media, including solid bodies, liquids, gases and vacuum. Engineering of high voltages. The department of high voltage engineering, laboratories of the Research Institute of Nuclear Physics (RINP), Electro-Energetical Faculty and Research Institute of High Voltages (RIHV) became the base of these researches.

2. Nuclear physics and acceleration engineering. The Physics Department of the Technical Faculty and RINP became the base of these researches.

3. Radiation physics of a solid body, which studies the phenomena in solid bodies induced by an impact of different radiations, including a laser radiation. Many departments and laboratories, in particular the Problem Laboratory of Dielectrics and Semiconductors Electronics (DSE), RINP laboratories and Research Institute Introscopy (RII) became the basis of these researches.

Many graduates of TPU and TSU, often being students, were involved in this work. Due to the great efforts of A.A. Vorobjev and his numerous colleagues and followers, the resource base and favourable medium for establishing an important scientific school were created in Tomsk Polytechnic University.

Under supervision of A.A. Vorobjev, a lot of TPU graduates devoted themselves to investigations of an

electrical breakdown and development of high voltage engineering. Afterwards many of them became professors of TPU and other higher education institutions.

In the late 1950s, high voltage impulse generators with a pulse duration of several nanoseconds up to hundreds nanoseconds were developed and constructed in TPU. One of the followers of A.A. Vorobjev, his namesake - Grigorij Abramovich Vorobjev, made a remarkable discovery. (Now, G.A. Vorobjev is a professor of the Physical Electronics Department (founded by himself), in Tomsk State University of Control Systems and Radioelectronics). If the electrodes are applied to the surface of a solid body and a direct voltage is supplied, then a breakdown occurs along the dielectric surface. And if a short pulse is supplied, then the breakdown occurs through the dielectric volume and results in a mechanical destruction and a chop of a solid body. This discovery formed the base of an electroimpulse technique for crushing mountain breeds and other dielectric materials suggested by A.A. Vorobjev and G.A. Vorobjev. Due to the efforts of many talented designers of the RIHV at TPU, electroimpulse crushing machines with a high efficiency were developed. TPU is the largest developer and manufacturer of this equipment in the world market. Electroimpulse crushing machines developed and manufactured in Tomsk Polytechnic University were sold to Japan, Germany and other countries. This year G.A. Vorobjev with co-authors, who unfortunately deceased, have received the diploma confirming the discovery made in TPU.

A.A. Vorobjev and G.A. Vorobjev were actively involving gifted young people, mainly from the students of TPU, to researches. G.A. Mesyats is one of them.

Gennadij Andreevich Mesyats (1936) is one of the most gifted followers of A.A. Vorobjev and G.A. Vorobjev, a graduate of the Electroengineering Faculty of TPU (now he is an academician, the first Vice-President of the Russian Academy of Sciences, a prizewinner of the State and International Awards). At that time he investigated an electrical breakdown caused by impact of nanosecond impulses of high

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voltage. In 1958 G.A. Vorobjev suggested a schematic diagram of a cascade generator providing high-voltage impulses with nanosecond pulse rise time and received the invention patent («millimicrosecond» corresponds to «nanosecond»). Using this generator, the group of G.A. Mesyats (S.P. Bugaev was among them) started intensive researches of the electrical discharge in vacuum, high pressure gases and along the surface of a solid body. It was when S.P. Bugaev made his first scientific work, which became a precursor of an outstanding scientific discovery of an explosive electron emission. He investigated a discharge along the surface of a dielectric in vacuum under an impact of high-voltage impulses with micro and nanosecond pulse rise time of voltage increase. The discharge along the surface of a solid is called «flashover» in English scientific literature. And up to now the work of S.P. Bugaev is quoted as a classical pioneering work on a flashover with nanosecond impulses. In 1965 S.P. Bugaev revealed that developing strong purely electron current, i.e. powerful electrons emission is followed by electric discharge along the surface. Then S.P. Bugaev and D.I. Proskurovsky went to Novosibirsk to the Institute of Nuclear Physics (SB RAS) and there, using the electronic-optical converters of high time resolution, directly observed this phenomenon - abrupt amplification of an electronic current preceding to filling of a vacuum gap with ion-electronic plasma and developing a vacuum discharge. Thus, the investigation of the explosive emission of electrons from metal edges - the main discovery of G.A. Mesyats, S.P. Bugaev, D.I. Proskurovsky, et al, started. Afterwards they received the diploma for the discovery, which became a source of many scientific and technical achievements of this scientific direction formed in TPU by its graduates. In 1968 G.A. Mesyats, B.M. Kovalchuk, V.V. Kremnev, S.P. Bugaev were awarded by Lenin's Komsomol Prize - the most prestige scientific award for young scientists at Soviet times, for developing the powerful nanosecond impulse devices and their application in physics and engineering.

In 1967 S.P. Bugaev defended his Candidate Thesis, and in 1976 he became Doctor of Technical Science and professor.

In the early 1970s, the Siberian Branch of the USSR Academy of Sciences was established in Tomsk. In 1977 G.A. Mesyats with his co-workers organized a new academic institute -

the Institute of High Current Electronics (IHCE), which in collaboration with TPU became one of the leading world centres of high current accelerators. Large contribution to investigation of explosive emission, development and application of high current accelerators and organization of the IHCE of Siberian Branch of the Russian Academy of Sciences was made by the co-workers of G.A. Mesyats, who were TPU graduates: the RAS academicians B.M. Kovalchuk and S.P. Bugaev, the RAS corresponding members Yu.A. Kotov, V.G. Shpak, professors D.I. Proskurovsky, Yu.E. Kreindel, P.M. Schanin, F.Ya. Zagulov, Yu.I. Bychkov. This year the Institute of High Current Electronics celebrated 23 years. G.A. Mesyats was its first Director, and S.P. Bugaev has been the Director since 1985 up to now.

In 1985 G.A. Mesyats became the Chairman of the Ural Branch of the RAS. He moved to Ekaterinburg and established the Institute of Electrophysics of UB RAS there. In 1985 S.P. Bugaev became the Director of IHCE of SB RAS. In 1987 he was elected a Corresponding Member, and in 2000 he became the RAS Academician.

Now, S.P. Bugaev is known in the world as a large expert in the field of electrical discharge physics, vacuum and plasma electronics, as an author and co-author of 190 scientific works including two monographs: «Electronic beams with a large section» (Moscow, Energoatomizdat Publ., 1984) and «Relativistic multiwave microwave generators» (Novosibirsk, Science Publ., 1991; it was translated and issued in China in 1995), a prize-winner of the State and Lenin's Komsomol Awards.

S.P. Bugaev is one of the founders of a new scientific direction - high current emission electronics, based on the explosive electron emission phenomenon, and a co-author of its discovery. These investigations were the base for the development of high current nanosecond accelerators and sources of electron beams with a large section intended for powerful gas lasers pumping. In the field of relativistic high current electronics, S.P. Bugaev together with his co-workers created and investigated the Cherenkov and diffractional microwave generators of centimeter and millimeter wavelengths on 10 sm. dia electron beams. Using these generators, the microwave radiation impulses with the record power 3 GW and 15 GW for the 0,8-3 sm wavelengths were achieved. In investigating the recom-

binning gas discharge chemically active plasma of the impulse discharges of atmospheric pressure, S.P. Bugaev and his co-workers discovered a phenomenon of a stimulated condensation of intermediate products of an oxidizing conversion of hydrocarbons, which led to fast removing of partial oxidation products from the gas phase. These investigations are promising in term of creating effective plasma chemical reactors creation for synthesis of some organic substances and gases purification. S.P. Bugaev gives a large attention to implementation of scientific achievements in practice. Under his supervision, the programme «Equipment and know-how of heat-saving glasses manufacture under cold climatic conditions», supported by the Russian Fund of Technological Development, is being carried out.

Since 1985 I have been the head of the Nonlinear Physics Laboratory of IHCE SB RAS and have regular contacts with Sergey Petrovich as the Institute Director. It is my opinion that S.P. Bugaev is an outstanding organizer of science. The proof is more than obvious. Now, IHCE SB RAS is the best research institute in Tomsk among all other academic and sectorial institutes and higher education institutions. And not only in Tomsk. I think that it is one of the best in Siberian Branch and the Russian Academy of Sciences as a whole.

Some years ago I was struck by the idea of the academician I.E. Tamm that the organizational talent in science is the highest one. I.E. Tamm is one of the Russian prominent scientists, Nobel premium winner for the Vavilov-Cherenkov effect theory. He is the founder of the theoretical school of the RAS Physical institute. His followers were the outstanding theorists: the academicians A.D. Sakharov, V.L. Ginzburg, V.L. Keldysh. Formerly I did not understand how it was possible to prefer organizational talent to the talent of discovering new phenomena and creating new knowledge - the main result of scientific activities. Only later I understood the depth of these words of academician Tamm, in particular, observing the activities of S.P. Bugaev. For him, the Institute of High Current Electronics is the aim of all his life.

Bugaev is a hard leader. And sometimes he is superhard one. He tends to build the Institute activities on democratic principles. In Russia, democracy is connected with liberalism and overstepping the bounds of decency. This is a fallacy. Democracy is the strict obedience to the law, the rules accepted by the majority. The director initiates a discussion of all major problems of the Institute activities on the Scientific Council: scientific directions, structures, orders, international and domestic contacts, competence of young scientists - candidates and doctors of sciences, etc. It is difficult to mention all the problems. But after the order comes in force, the Director requires its strict observance by all subdivisions and employees. In essence, all the civilized world lives in accordance with such rules, but in Russia there are only separate «islands». IHCE SB RAS is such an «island». Only when these «islands» merge in the «continent», Russia will become a successful country. As an organizer of science, S.P. Bugaev has intuition and insight to see future. The years of reconstruction (perestroika) were the hard times for the Russian science. In the late 1980s and early 1990s, the state financing of science was reduced more than 20 times. Many scientific institutes disappeared, other ones were essentially reduced. I remember how Sergey Petrovich, at the beginning of this difficult decade, invited us - the laboratory heads and declared the principle of subdivision self-sufficiency. Sincerely speaking, do not wait for a miracle and learn to earn money for research by selling the scientific activity results. And the majority of subdivisions has survived. Now IHCE SB RAS has a strong foundation. One can name large dollar contracts with China, France, England, USA, Japan. The Institute of High Current Electronics is a leader in its area and has been recognized by the world scientific community. And a large merit in it belongs to the Director, academician S.P. Bugaev.

All polytechnicians and graduates of Tomsk Polytechnic University working in other places congratulate Sergey Petrovich Bugaev, the IHCE Director, with his being elected in the Russian Academy of Science.