

## In memory of Dmitry Kovalev (1961-2015).



*Dmitry Kovalev began the study of porous silicon in the beginning of the 90s and he published many outstanding original works and several reviews, which are widely cited now. He was a brilliant researcher in the fields of semiconductor physics and optics. His fundamental studies of the photoluminescence and birefringence of porous silicon gave a great impact to understanding of the optical properties of semiconductor nanostructures. He was always open to discover new phenomena and applications of porous silicon. His pioneering works on the explosive reaction of molecular oxygen with porous silicon and on the photosensitized generation of singlet oxygen have determined new areas of application of this material.*

Dmitry Igorevich Kovalev was born in St. Petersburg, Russia, on July 18th, 1961. He received a Ph.D. in Physics at the Ioffe Physical Technical Institute, St. Petersburg, Russia, in 1989. From 1989 to 1994 he was a Research Associate at IPTI. In 1994 he joined the Physics Department E16 of Technical University of Munich (TUM) as a Fellow of the Alexander von Humboldt Foundation. Since 1996 he had been working in TUM firstly as a Researcher, and, after finishing his habilitation in 2001, he was a Senior Researcher in the same department. There he was involved in the teaching of the experimental physics and his lectures were always outstandingly deep and exciting for students. In the end of 2005 he moved to England and became a full Professor at the Department of Physics, University of Bath, UK. He died in St. Petersburg, Russia, on January 25th, 2015.

Dmitry began his research in physics, being a Student of a special group at the Department of Optoelectronics in Electrical Engineering University in St. Petersburg where Prof. Zh. I. Alferov was a Head of the Department. In 1985 Dmitry completed a Master thesis devoted to a study of the exciton luminescence in semiconductors in crossed magnetic and electric fields. Since 1985 to 1994 Dmitry became a Staff member of the Department of Semiconductors of IPTI. His PhD work on the interaction of non-equilibrium acoustic phonons with excitons in semiconductors, which was supervised by Prof. I. D. Yaroshetskii, was completed in 1989. After the PhD work, Dmitry actively began to explore porous silicon (PSi), which was a new material at that time. These studies resulted in a discovery of the short-lived green photoluminescence band in PSi [1].

The most fruitful period of Dmitry's research work started in 1994, when he became an Alexander von Humboldt Fellow at the Physics Department E16, headed by Prof. Frederick Koch, in TUM. At that time he intensively investigated the photoluminescence (PL) of PSi to clarify the origin of light emission in this material. There his studies resulted in a discovery of "fast" and "slow" luminescence bands in oxidized PSi [2]. Along with the study of PL lifetimes he was one of the first who drew attention to the anisotropy of the optical properties of PSi [3]. Numerous studies of the optical properties of PSi were summarized by Dmitry in a review published in 1999 [4]. This outstanding review remains highly cited up to now. The main result of Dmitry's research at that time was a conclusion that the "red" photoluminescence band of porous silicon was related to partially-allowed excitonic transitions in Si nanocrystals. His papers on the breakdown of the k-conservation rule [5], determination of the optical cross section of Si nanocrystals [6], and birefringence [7-10] are belonging to the best examples of the fundamental studies of PSi.

Along with the optical studies of PSi, Dmitry together with co-authors published series of pioneering papers on explosive reaction of molecular oxygen with PSi [11,12] and photosensitized generation of singlet oxygen by PSi [13,14], which opened new areas for applications of this material. Dmitry's works showed that the excitation of singlet oxygen in PSi occurs via the direct electron transfer from photoexcited nanocrystals to molecular oxygen and this effect was proposed for biomedical application as photodynamic therapy of cancer. The main achievements in investigations of PSi as a photosensitizer of singlet oxygen generation were presented in a review [15]. The first evidence of the photosensitizing effect of PSi in vitro was demonstrated soon [16].

The last period of the research activity of Dmitry Kovalev was devoted to different applications of PSi-based materials in photonics [17], acoustics [18], photocatalysis [19], biomedicine [20], hydrogen production [21], and solar cells [22]. Dmitry suggested that successful applications of the light emitting properties of PSi could be possible after a strong enhancement of the probability of radiative transitions by modification of the interface between silicon nanocrystals and surrounding medium [17]. He believed that PSi could be a useful material for alternative energy sources [21,22]. It seems that these predictions, which are based on his deep understanding of the nature of PSi, can be a reliable guide for future researchers.

We, those who read the papers of Dmitry Kovalev and especially knew him personally, will always remember his bright creative personality, huge energy research, depth of analysis of the studied phenomena and a sincere devotion to the Science.

### **Dmitry Kovalev: Selected Papers**

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