

# Preface

Being tightly technologically oriented, the contemporary scientific knowledge often suffers from lack of passion. The present book, dedicated to two distinguished scholars, Prof. Iwan N. Stranski and Prof. Rostislaw Kaischew, intends to illuminate this ardor as a state of the human mind moving science forward.

In the 1920s, Iwan N. Stranski along with Walther Kossel, introduced one of the fundamental physical concepts in crystal growth, “the half-crystal position” or kink site, implemented later in the classical Kossel–Stranski model of the crystal structure. In 1938 Stranski and Krastanow discovered the famous Stranski–Krastanow growth mode of epitaxial layers. In 1934 Stranski and Kaischew formulated the theory of mean separation work, revealing thereby the identity of the thermodynamic and kinetic approaches to Gibbs’s problem of the equilibrium of small phases. In the same year they published the first kinetic treatment of the nucleation rate of crystals, droplets, and bubbles. On that background, Stranski and Kaischew developed in great detail fundamental aspects of nucleation theory, equilibrium shape of crystals, homo- and heteroepitaxial growth of thin atomic layers, and electrocrystallization. In a series of studies in 1950–1951, Kaischew extended the Gibbs–Curie–Wulff theorem of equilibrium shape of crystals to the case of crystals on foreign substrate. This refinement, known as “generalized Gibbs–Curie–Wulff–Kaischew theorem,” and the conditions derived for two- or three-dimensional nucleation on a foreign substrate formed later the theoretical background of thin epitaxial film growth. These highlights of the Sofia school in crystal growth as well as the outstanding scientific life and personality of both Iwan N. Stranski and Rostislaw Kaischew have inspired the present edition.

The influence of Stranski’s and Kaischew’s scientific style on their coworkers and students has been immense. I had no chance to meet Stranski personally, but I had the privilege of working in Kaischew’s Department of Crystal Growth at the Institute of Physical Chemistry in Sofia for more than 25 years and my impressions of his outstanding life stem from that time. Rostislaw Kaischew was a man of vision and strong scientific intuition. Being a fascinating teacher, he possessed the talent of attracting people and involving them in science. Founder of the Institute of Physical Chemistry at the Bulgarian Academy of Sciences, Kaischew was its director for more than 30 years (1958–1989).

The personality of Iwan N. Stranski was strongly respectable. Consecutively, as founder and head of the Department of Physical Chemistry at Sofia University (1925–1944), director of the Institute of Physical Chemistry at the Technical University in Berlin (1944–1949), rector of the Technical University in Berlin (1951–1953), and deputy director of the Fritz Haber Institute of Physical Chemistry at the Max Planck Society (1953–1967), Iwan N. Stranski, known as the father of crystal growth, had a great impact on the international academic and research community.

A distinctive feature of the scientific ideas of Stranski and Kaischew, implemented in the classical theory of phase formation, is their simplicity. The model they have introduced in crystal growth reflects in a nice and proper way Karl Popper's concept of science: "The method of science depends on our attempts to describe the world with simple theories: theories that are complex may become untestable, even if they happen to be true. Science may be described as the art of systematic over-simplification – the art of discerning what we may with advantage omit." The invention of the kink site and the theory of mean separation work are probably one of the best examples of Popper's thought. In 1996 during the second Stranski–Kaischew conference in Pamporovo Ski Center, Bulgaria, the fascinating speaker Joost Frenken demonstrated for the first time a spectacular high-temperature STM movie, revealing real-time attachment and detachment of individual atoms at atomic steps and kinks. Kaischew, 88 years old at that time, attended the lecture. At the end of the talk, deeply moved, he said, "I have never believed that in my life I would be blessed to see direct experimental evidence of our imagination of the mechanisms of crystal growth. Even being so simple, our model suggested in 1934 seems to be true."

Most of the authors contributing to this book are among the founders of the Stranski–Kaischew crystal growth club established in the early 1990s by a series of international meetings in Bulgaria. In 1992–1993, I spent a year as a coworker of Boyan Mutaftschiev in his laboratory in CNRS, Nancy, and that was the place and time where these meetings have been inspired. Being a close friend of Stranski and a favorite student of Kaischew, Boyan was a keen connoisseur of the history of crystal growth. He had the gift to fascinate people by involving them in the values of "the old time of classical science." Actually, our discussions in Nancy incited me to initiate this series of workshops on surface physics in Bulgaria. Kaischew strongly encouraged this idea and the first workshop was held in February 1994. Known at present as "Stranski–Kaischew Workshops in Surface Physics," these regular meetings have kept the spirit of the classical school in crystal growth and have attracted outstanding researchers in surface science. Kurt Binder, Harald Brune, Alex Chernov, Theodore Einstein, Joost Frenken, Doon Gibbs, Martin Henzler, Masakazu Ichikawa, Kenneth Jackson, Dimo Kashchiev, Raymond Kern, David Landau, Alexander Latyshev, Thomas Michely, Andrey Milchev, Chaouqui Misbah, Boyan Mutaftschiev, Anton Naumovets, Hiroo Omi, Herbert Pfnuer, Matthias Scheffler, Robert F. Sekerka, Stoyan Stoyanov, Kunio Takayanagi, Erio Tosatti, Michael Tringides, Peter Varga, Ellen Williams, and Zhenyu Zhang are among the lecturers who built up the reputation of this series of meetings. However, it is my personal privilege to acknowledge in a particular way two of them. David Landau

and Kurt Binder involved themselves in this project with extraordinary enthusiasm and great concern. Their contribution to the lectures, discussions, and scientific programs had been substantial in all past six workshops.

Aiming to find answers closer to the question “why” rather than “how” the things in surface physics happen, this enthusiastic team of scientists outlined the center of attention of Stranski–Kaischew meetings. This center is manifested by the title of the present volume too: “Nanophenomena at Surfaces: Fundamentals of Exotic Condensed Matter Properties.” A glance at the chapter titles shows a diversity of topics discoursed in this book. Being focused on the point “Why the matter has exotic behavior when the size of systems and their space dimensions are reduced?” this edition covers *Structure and properties of confined crystals on surfaces* (K. Binder), *Atomic interactions in two-dimensional overlayers* (T. Einstein), *Surface diffusion phenomena and surface pattern formation* (E. Williams and M. Michailov), *Quantum size effects in low-dimensional structures* (M. Tringides and Z. Zhang), *Electronic properties of nanostructures and metallic nano-wires* (M. Ichikawa and H. Pfner), *Biologically inspired nanophysics, proteins and polymer chains* (D. Landau and A. Milchev), *Step bunching phenomena* (A. Latyshev and S. Stoyanov). It is my hope that the reader will find here important bridges between classical, quantum, and nano concepts in condensed matter physics. Being dedicated to the memory of Iwan N. Stranski and Rostislaw Kaischew, I believe that the present book will stimulate further advances in nanoscale surface physics and will encourage young people in science.

Finally, I am grateful to my colleagues and friends from the Institute of Physical Chemistry in Sofia, Vessela Tsakova for her sincere support in sharing through hard times our common cause of Stranski–Kaischew meetings, Stoyan Stoyanov and Andrey Milchev for their valuable advices in program preparation, and Dimo Kashchiev for his ceaseless encouragement in the realization of the present book.

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