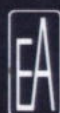


**THE MICRO- AND NANOELECTRONICS
SCHOOL IN ROMANIA**

A MONOGRAPH

**Coordinators:
DAN DASCĂLU
ANDREAS WILD**



EDITURA ACADEMIEI ROMÂNE

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A NOTE FROM THE EDITORS OF THE ENGLISH EDITION

This book is the edition in English of the volume in Romanian published in 2018 by the Romanian Academy Publishing House as a supplement to the Series "Romanian Civilization". Being produced a few years later, some sections represent an updated version of the addressed topics, while a few others are a translation of the Romanian text.

The contributors had to overcome a sad event, as the coordinator of this book, Acad. Dan Dascălu, passed away unexpectedly in February 2021, as he was pursuing with remarkable energy numerous projects, including finishing this book. This is also an homage that the participants in this project are bringing to Acad. Dascălu, in recognition for his essential, seminal, outstanding contributions to establishing, building up and then fighting for the survival of the Romanian school of micro- and nanoelectronics – the very subject of this book.

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This volume would not have existed without the initiative and tenacious involvement in writing, motivating the co-authors, and assembling their contributions of Acad. Dan Dascălu. After editing the first version in Romanian, he has been engaged strongly in elaborating the present version. Sadly, he is no longer with us to see his project accomplished.

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Prof. Gheorghe Ștefan, corresponding member of the Romanian Academy and interim President of the Commission for the Science and Technology of Microsystems, not only supported the publication but is also one of the contributors.

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The present text also includes segments written by other contributors that are mentioned in the respective paragraphs. In fact, many more colleagues and associates shared their information, memories, and viewpoints, and let the writers feel their enthusiasm in bringing forward this page of history. They all are given here a friendly acknowledgment.

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FOREWORD: ROMANIAN INVOLVEMENT IN HIGH TECHNOLOGY

DAN DASCĂLU

† 10 FEBRUARY 2021

The present book has been written as a supplement to the series “Romanian Civilization” issued by the Romanian Academy to celebrate the Centenary of the Great Union. It contains details regarding the establishment and development of micro- and nanoelectronics in Romania. It presents the Romanian school, in the broadest sense. It does not mean just a higher education institution, be that a university department or a doctoral school, but a real ecosystem, encompassing education, research and innovation, able to generate, share and apply knowledge, producing specialists with varied and complex competences, able to address real-life problems. Such an ecosystem could be found in Romania in the second half of the last century, driven by more than *individual initiatives or intellectual curiosity*. It was the result of a Government strategy and corresponding investments. In spite of all political handicaps, individual talent could flourish especially in the sixties and seventies, contributing to the development of a domestic industry and generating first class competence. The worsening of the life and work conditions in the eighties resulted in talent emigration, which accelerated after the events from December 1989 when the authorities renounced implementing policies in support of key domains. Today, in the field we address, Romania has a large and active diaspora that enjoys a high level of international recognition and keeps alive the professional links with the country of origin.

Micro- and nanoelectronics are related to the *semiconductor industry* that appeared in the fifties following invention of the *transistor*. The industry evolved in the sixties to manufacture electronic circuits with transistors integrated in a semiconductor chip of monocrystalline silicon. The name *microelectronics* has been coined after the invention of the microprocessor (1971). It was electronics at micrometric scale (one micron is one thousandth of one millimeter).

Miniaturization continued and the name was eventually changed to *nanoelectronics* when the feature size diminished down to the range of tens of nanometers (hundredths of micrometers). Nanoelectronics allowed to integrate in a single component extremely complex systems, for example processors built using billions of transistors. The capital investments required to build a manufacturing line increased enormously, but the extraordinary functionalities of reasonably priced components kept opening new markets, even for consumer applications. The astonishing progress achieved by the micro- and nanoelectronics in the last two

decades are briefly addressed in the introductory chapter, while Romania's prospective in re-entering semiconductor manufacturing is reviewed in the last chapter of this book.

It is important to consider from the beginning the important role *physics* is playing in this field. The transistor could not be invented without the thorough understanding of solid-state phenomena described by quantum mechanics. Physics explained what was going on in the increasingly complex electronic devices and circuits. And it is still in this branch of science that offers innovation opportunities to overcome the limitations of the current devices by harnessing new phenomena and new materials. Physics is also the foundation for building advanced manufacturing tools based on revolutionary principles.

In Romania, from the beginning, electronic devices and nuclear physics have been very close to each other. Professor Tudor Tănăsescu, the head of the *Electronic Valves, Transistors and Electronic Circuits* Chair at the Polytechnic Institute of Bucharest (abbreviated in Romanian as IPB) had also been the first Technical Manager at the Institute of Atomic Physics (Romanian abbreviation: IFA). The specialization in “physicist engineers” at the Department for Electronics and Telecommunications of the same University prepared for quite some time engineers with a dual competence in electronic devices and in nuclear physics. Both nuclear physics and electronics were considered priority topics by the Romanian Government. In this context, it is understandable that Chapter 7 of this volume is dedicated to *nuclear electronics*, authored by a graduate in the “physicist engineers” specialty who became General Manager of IFA.

The *electron devices school* headed by Professor Mihai Drăgănescu has been the essential element in educating specialists in micro- and nanoelectronics. He was doctoral adviser at the FETc within IPB and was then received in the Romanian Academy (Chapter 2). Many Ph.D. students of Prof. Drăgănescu became important decision makers contributing to the institutional development in Romania, but most specialists involved in research and industrial activities have been grown in the ecosystem, at their “working place”– as it was customary to say in those times. Chapter 3 to 5 are authored by the protagonists of these activities. They describe the evolution of the main entities in the field, convincingly demonstrating to which extent the success was the result of their ingenuity and dedication. An *annual scientific conference* started in those times survived more than four decades at international standards, being an important vehicle in connecting the specialists and facilitating communication. *The professional community in Romania was relatively, but not completely isolated* from the rest of the world. Some specialists could get an assignment for specialization in particular areas in western countries, there were trainings provided when equipment items were purchased or licenses were acquired, some specialist could even attend international conferences. Those who were not allowed to travel could still publish in western publications.

The profound societal changes after the events from December 1989 have disturbed the professional community in the field. Nowhere was the *disintegration* of the field more obvious than on the Băneasa platform, where the semiconductor industry was concentrated (including a microelectronics fab). The manufacturing lines became scrap. The *designers of integrated circuits* could continue in their profession only if they could join foreign companies abroad (Chapter 8). The National Institute of Microtechnology (Chapter 6) that embodied an idea of Professor Drăgănescu, managed to regroup a few specialists remaining in the country and establish a competitive research infrastructure for *niche* domains (microsensors, microwave devices, carbon-based nanomaterials). The Institute also provides support for the Doctoral School of the FETTI of UPB (that also teaches power electronics, Chapter 2).

Romanian researchers currently expatriated (Chapter 9) cover a large spectrum of topics. The *veterans* have been usually successful in building careers inside established companies, the newer generations also got tenures at various Universities. Keeping alive the links to this numerous and remarkably performant diaspora represents a chance for the survival of the domain in Romania.

Yet, the title *Romanian Involvement in High Technology* does not refer exclusively to the diaspora. A strong case is made by the successful involvement in the research programs promoted by the European Union (in particular in *microsystems*, Chapter 6). The *micro-nano* technologies demonstrated their capabilities in the programs of the European Space Agency and in large projects like the *Extreme Light Infrastructure* (ELI), while the interest is strongly increasing in security applications. An important potential exists also in the collaboration with the automotive industry. Romania seems to have some advantages (human resources, research infrastructure), including in regional cooperation, even if these opportunities are far from being properly exploited.

Finally, the collaboration possibilities with foreign companies have been already demonstrated for design activities (Chapter 8); also, the foreign investment should not be overlooked (Chapter 10). On the other side, the prospective could be considered in a different context, that of nanotechnologies in the broadest sense (key enabling technologies with multiple applications). Such an approach can enroll higher resources to achieve a critical mass but must avoid lacking focus: there is a need for a thought-through national strategy (Chapter 6).

We express our recognition for all those who answered positively the invitation to contribute to this remembering the domain evolution. The resulting story may be incomplete and imperfect, but this first attempt can open the way for a better structured, all-encompassing material in the future.