

Preface

This book covers multiple facets of micro and smart systems technologies. Miniaturization of sensors and actuators through effective use of smart materials forms the core of the book. Related aspects of material processing and characterization; modeling and simulation; and applications are also given due importance. Twenty nine chapters written by competent research teams from academia and government research labs comprise a valuable resource that gives a bird's-eye view of the state of the art of the field in India. While the technological details of the work described in this book are self-explanatory, it is pertinent to introspect on how it all happened in India not too long after the miniaturization revolution transpired elsewhere in the world.

Generous financial support and guidance from the government, vision and driving force of a leader, and a professional society that can enthuse an able workforce are perhaps three necessary factors to initiate and establish a new research area in a country. India has had all of these in the last 15 years to lay a firm foundation for micro and smart systems technologies. First, the Defence Research and Development Organisation (DRDO) and four other science and technology departments of the Government of India, initiated and ran two large research programs, namely, National Programme on Smart Materials (NPSM, 2000–2006) and National Programme on Micro and Smart Materials and Systems (NPMASS, 2007–2014), with a combined budget of nearly Rs. 270 crores (\$45 M today). Second, Prof. V. K. Aatre, gave unstinted leadership and support to numerous researchers and research administrators whom he inspired and nurtured. Third, a professional society, ambitiously christened, the *Institute of Smart Structures and Systems* (ISSS) was founded in 1998 to bring together experts from multiple disciplines to create a research community in micro and smart systems in India. As a result of these efforts, India today is proud to claim its presence in the field. This edited monograph, with the exception of one chapter, is a record of the work done in India and thus it stands as a testimony to the success of a well-conceived and ably executed endeavor.

Many researchers from the academia and government research laboratories contributed to NPSM and NPMASS, which were admirably administered by the Aeronautical Development Agency (ADA) under the guidance of the Board for Smart materials Research and Technology (B-SMART). Constant support from the past and present Heads of DRDO and its higher management has helped run these

programs well. Program offices of NPSM and NPMASS, which operated out of ADA, Bangalore, since 2000, did exemplary work in liaising with various arms of the programs and grantees, bringing synergy and effective program management. The chairs and members of Programme Assessment and Recommendation Committees (PARCs) looked after the technical details of the funded projects. The result of the untiring efforts of all these and many more individuals—too many to mention here—is widespread awareness of micro and smart systems technologies and engagement into research and development activities in almost all parts of India. NPSM and NPMASS have paid particular attention to human resource development by establishing more than 65 National MEMS Design Centres (NMDCs) in many states of India covering the length and breadth of the country. Hundreds of researchers have been involved in more than 150 projects funded by NPSM and NPMASS.

The most significant outcome of this concerted effort is that the spirit of multidisciplinary research in micro and smart technologies now pervades all parts of India. Most researchers began with modeling and design. Not too long ago in India, possessing a license of a microsystems simulation software meant being engaged in research in this area. But today it has changed; with the establishment of state-of-the-art well-equipped cleanrooms and characterization facilities, researchers in India are able to fabricate and even package devices and systems. All aspects of the field, development of microsensors and microactuators; material processing and characterization; fabrication; advanced modeling, design, and simulation; and systems design have all begun. Packaging and transfer of technology have also commenced. The chapters in this book are indeed organized accordingly.

The final link in this chain of events is commercialization of the developed technology. This step needs conscious effort and copious resources, perhaps an order of magnitude more than what went into creating the able research community. The time is now ripe to involve the established industries and to nurture entrepreneurship. One hopes that the same level of commitment and financial support will be given to incubating companies in micro and smart technologies in order to create a thriving industry in these areas in India.

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K. J. Vinoy
G. K. Ananthasuresh
Rudra Pratap
S. B. Krupanidhi

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Vinoy, K.J.; Ananthasuresh, G.K.; Pratap, R.; Krupanidhi,
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