Smart Material Systems and MEMS: Design and Development Methodologies

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Preface

'Smart technology' is a term extensively used in all branches of science and engineering due to its immense potential in application areas of very high significance to mankind. This technology has already been used in addressing several remaining challenges in aerospace, automotive, civil, mechanical, biomedical and communication engineering disciplines. This has been made possible by a series of innovations in developing materials which exhibit features such as electromechanical/ magnetomechanical coupling. In other words, these materials could be used to convert one form of energy (say electrical) to another (mechanical, e.g. force, vibration, displacement, etc.). Furthermore, this phenomenon is found to be reciprocal, paving the way for fabricating both sensors and actuators with the same materials. Such a system will also include a control mechanism that responds to the signals from the sensors and determines the responses of the actuators accordingly.

Researchers the world over have devised various ways to embed these components in order to introduce 'smartness' in a system. Originally introduced in larger systems in the bulk form, this science is increasingly leaning towards miniaturization with the popularization of micro electromechanical systems (MEMS). One of the reasons for this is the stringent lightweight constraints imposed on the system design. Although there have been sporadic efforts on various facets of the technology, to the best of these authors' knowledge, there is currently no single book dealing with diverse aspects such as design, modeling and fabrication of both bulk sensors and actuators and MEMS.

The use of MEMS in smart systems is so intensely intertwined that these technologies are often treated as two 'faces of the same coin'. The engineering of smart systems and MEMS are areas for multidisciplinary research, already laden with myriad technological issues of their own. Hence, the books presently available in the literature tend to separate the basic smart concepts, design and modeling of sensors and actuators and MEMS design and fabrication. Evidently, the books presently available do not address modeling of smart systems as a whole. With smart systems technology branching towards several newer disciplines, it is essential and timely to consolidate the technological advances in selected areas.

In this present book, it is proposed to give a unified treatment of the above concepts 'under a single umbrella'. This book can be used as a reference material/textbook for a graduate level course on Smart Structures and MEMS. It should also be very useful to practicing researchers in all branches of science and engineering and interested in possible applications where they can use this technology. The book will present unified schemes for the design and modeling of smart systems, address their fabrication and cover challenges that may be encountered in typical application areas.

Material for this book has been taken from several advanced short courses presented by the authors in various meetings throughout the world. Valuable comments from the participants of these courses have helped in evolving the contents of this text and are greatly appreciated. We are also indebted to various researchers for their valuable contributions cited in this book. We would like to indicate that this text is a compilation of the work of many people. We cannot be held responsible for the designs and development methods that have been published but are still under further research investigation. It is also difficult to always give proper credit to those who are the originators of new concepts and the inventors of new methods. We hope that there are not too many such errors and will appreciate it if readers could bring the errors that they discover to our attention. We are also grateful to the publisher's staff for their support, encouragement and willingness to give prompt assistance during this book project.

There are many people to whom we owe our sincere thanks for helping us to prepare this book. However, space dictates that only a few of them can receive

formal acknowledgement. However, this should not be taken as a disparagement of those whose contributions remain anonymous. Our foremost appreciation goes to Dr V.K. Aatre, Former Scientific Advisor to the Defence Minister, Defence Research and Development Organization (DRDO), India and to Dr S. Pillai, Chief Controller of Research and Development, DRDO, for their encouragement and support along the way. In addition, we wish to thank many of our colleagues and students, including K.A. Jose, A. Mehta, B. Zhu, Y. Sha, H. Yoon, J. Xie, T. Ji, J. Kim, R. Mahapatra, D.P. Ghosh, C.V.S. Sastry, A. Chakraboty, M. Mitra, S. Jose, O. Jayan and A. Roy for their contributions in preparing the manuscript for this book. We are very grateful to the staff of John Wiley & Sons, Ltd, Chichester, UK, for their helpful efforts and cheerful professionalism during this project.

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