

# Book Review

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## **SMART STRUCTURES: PHYSICAL BEHAVIOUR, MATHEMATICAL MODELLING AND APPLICATIONS**

P Gaudenzi, 194 pp., John Wiley & Sons, 2009, £75.00 (hardback), ISBN 978-0-470-05982-1

The title of this book suggests it gives an overview of the huge research effort in the understanding, modelling and application of smart structures. In fact the contribution is not so wide ranging, and although the book gives a brief introduction to a range of smart materials, it really concentrates on piezoelectric materials and gives general analysis for strain actuators and sensors.

The first chapter motivates the area of smart structures well and provides a link to active materials. This chapter then introduces common active materials: piezoelectric are reviewed in detail including an understanding of the crystal structure and the constitutive laws; a physical understanding of shape memory alloys is given using the transition between the austenite and martensite phases; magnetostrictive and electrostrictive materials are overviewed briefly. Although the title implies a range of smart structures are covered, the remainder of the book is really concerned with piezoelectric materials. The first chapter concludes with an overview of four popular applications of smart structures, namely structural health monitoring, shape morphing, vibration control and energy harvesting.

Chapter 2 takes the constitutive model from chapter 1 and incorporates this model into a general analysis of structures containing piezoelectric material. Examples are given where detailed analysis of the electrical potential and mechanical strain are required, such as in the design of piezoelectric actuators using interdigitated electrodes.

Chapter 3 presents techniques to analyse systems with strain actuators and sensors. Most smart materials essentially work as an actuator through an induced strain mechanism, and the author summarises the physical processes for inducing this strain for a range of smart materials. The physical basis of concepts such as actuator strain and blocking force are explained. Various systems of

beams with strain actuator patches on the surface are then modelled from first principles. Simple pin-force models are introduced, and their accuracy demonstrated when the actuator thickness is small relative to the beam thickness. The effect of the actuator length and position on the excitation of the lower modes is shown. The chapter also considers piezoelectric patches as sensors, including some discussion on signal conditioning, and gives a brief introduction to control issues, although the author only considers proportional and derivative control.

Chapter 4 combines piezoelectric material with other material to produce an active composite. The chapter concentrates on two major applications, namely the analysis of actuators with interdigitated electrodes based on either piezoelectric plates or fibres, and the introduction of piezoelectric layers into classical laminated composite shells. The final chapter gives a brief summary of three applications of piezoelectric materials for spacecraft: shape control of an antenna; vibration control of an optical payload; and an ultrasonic motor.

The book represents a good introduction to the modelling and analysis of structures with piezoelectric sensors and actuators. Of particular merit is the development of the models and analysis from first principles. However it is not exactly clear to the reviewer who the target audience is. The book contains suitable material for a senior undergraduate or masters level course to introduce smart structures, although the chapters do not have any problems for students to attempt, which a textbook would normally have. The book could be used as an introduction for new researchers in the field, although they would very quickly outgrow the book and would then have to move to other books and papers. Despite these reservations, this book represents a welcome addition for new and established researchers in the field, and will also find a place in courses teaching smart materials.

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