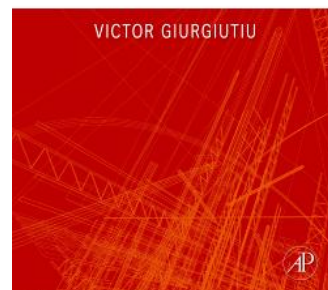


STRUCTURAL HEALTH MONITORING WITH PIEZOELECTRIC WAFER ACTIVE SENSORS

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In this issue of the journal we have the opportunity to present an editorial brand, otherwise immediately retrievable with a simple search on Google (“the most comprehensive text/reference yet written on all aspects of Structural Health Monitoring”). Indeed, there are not many publishing houses that can compete with Elsevier, and the author is undoubtedly a reference name of a domain of growing interest.

It suffices to mention that, for example, the United States spends between 5 and 10% of its budget each year on the maintenance of plant, equipment and facilities. The *structural health monitoring* (SHM) involves just the observation of a system over time periodically using sampled dynamic response measurements from sensors, the extraction of damage-sensitive features from these measurements, and the statistical analysis of these features to determine the current state of system health. For long term SHM, the output of the process is periodically updated with information regarding the ability of the structure to perform its intended function in spite of the inevitable aging and degradation resulting from operational environments. The benefit is to manage the *mean time to fault*, a concept from the reliability theory, and thus to reduce the maintenance costs, accordingly. The book presents an integrated approach of SHM, using as a case study the *piezoelectric wafer active sensors* (PWAS). PWAS are small, lightweight, inexpensive, non-intrusive, un-obtrusive devices that can be surface-mounted on existing structures, or inserted in a new composite structure. The PWAS can be used in both active and passive modes. In *active mode*, the PWAS generate Lamb waves that can exist as either traveling waves or standing waves. As traveling waves, PWAS-generated Lamb waves can be used with the *pitch-catch*, *pulse-echo*, or *phased array methods* that allow far-field and some medium-field damage detection. As standing waves, PWAS-generated Lamb waves can be used in conjunction with the *electro-mechanical (E/M) impedance technique* that allows near field and some medium-field damage detection. Considering the typology of waves, these methods are classified as: (a) embedded guided-wave ultrasonics, i.e., pitch-catch, pulse-echo, phased arrays; (b) thickness mode wave propagation; (c) high-frequency modal sensing, i.e., the electro-mechanical (E/M) impedance method; (d) passive detection, i.e., acoustic emission and impact detection. Thus, pulse-echo method is an ultrasonic non-destructive testing “for the detection and characterization of defects in composites in which pulses are transmitted and received on the same side of the test panel after being reflected from the opposite face; defects cause a decrease in the reflection amplitude”. The book gathers together a series of contributions of the author. Professor Giurgiutiu was the first to analytically prove the experimental observation that the real part of the electrical impedance measured at the PWAS terminals actually represents the high-frequency local spectrum of mechanical resonances of the structure on which the PWAS is attached and thus establishing the term “electromechanical (E/M) impedance”.

Professor Giurgiutiu also established the PWAS tuning principles for excitation/detection of selective Lamb wave modes through a combination of frequency, PWAS size, and Lamb mode wavelength and proved it by rigorous theoretical analysis, numerical simulations, and experimental validation. The *PWAS tuning principles* were subsequently applied to the detection of various damage types such as crack, corrosion, and delamination by selecting the appropriate Lamb-wave mode, which is more sensitive to a certain damage type, thus enhancing detectability. Last but not least, Professor Giurgiutiu has developed the *PWAS phased arrays* concept that “combines the well-known phased-array principle with the above-mentioned PWAS tuning principle to generate steered beams of single-mode low-dispersion guided waves traveling in thin-wall structures”; the citations refers, of course, at some texts the author. Although phased arrays have been used for some time in conventional ultrasonic non-destructive evaluation and bulk waves, his novel contribution consists in using this principle with PWAS transducers and guided waves, which was made possible by his previous work on PWAS tuning. The tuned steering beam of single-mode guided waves were used to cover large structural areas from a single location. Dubbed “*embedded ultrasonics structural radar (EUSR)*”, this method has been successfully demonstrated first on simple geometries and next on actual aircraft parts.

I think it is useful to enumerate the most interesting chapters, in my view, of this impressive monograph: 6. Guided waves; 7. Piezoelectric wafer active sensors; 8. Tuned waves generated with PWAS; 9. ... The electromechanical impedance method; 10. Wave propagation SHM with PWAS; 11. In-situ phased arrays with PWAS; 12. Signal processing and pattern recognition for PWAS-based SHM. Appendix A (Mathematical prerequisites), Appendix B (Elasticity notations and equations), Bibliography (12 pages) and Index (37 pages) are made in terms of reader interest.

Professor Victor Giurgiutiu was recently invited to present a conference in INCAS. The conference material can be found at the address:

www.incas.ro/images/stories/home/20120711%20LAMSS_PWAS_SHM-NDE.pdf

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