# Smart Structures

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Over the past decade, a new interdisciplinary field of research called ‘‘smart structures’’ has emerged. A smart structure can be generally described as a nonbiological structure that has a definite designed-in purpose and the ‘‘will’’ and means to actively try to achieve that purpose. In some sense, a smart structure would be a nonbiological analog of a living structure such as a tree. Trees adapt and change their internal structures based on changes in their external environments by strengthening certain parts, extending their roots to find water, etc. The field as we know it today evolved out of research in the early 1980s to integrate radar antennas into the skins of military aircraft, so-called smart skins. If anyone can be seen as the founder or catalyst for the creation of smart structures research, it is Eric Udd, formerly of McDonnell Douglas and now of Blue Road Research. During the Air Force R&D roadmap development process called Project Forecast II in 1984-85, he argued for extending the smart skins concept into one including the whole structure, with health monitoring and other possible functionalities, i.e., a smart structure. The idea took hold and with Air Force support by Captain C. Mazur, Dr. G. Sendeckyj, and others, the field was born.

Enabling technologies for smart structures include designed materials, advanced actuation and sensing techniques, adaptive computer algorithms with the ability to learn and provide control outputs, and finally methods whereby energy usage can be optimized. In the end, it is a case of attempting to create something in which the whole is greater than the sum of its parts, mirroring what happens in the integrated biological systems that we see in nature. Applications for the technology range from spacecraft and aircraft to large civil structures such as skyscrapers and bridges. Optical technology in particular has played a large part in the development of smart structures. In this special section, a number of papers that range from enabling technologies to integrated systems are presented to give a flavor of the different ways in which optics is impacting the field of smart structures.

The first several papers of the special section are concerned with adaptive optical systems. Systems of this type represent the most fully realized smart structures to date. In the paper ‘‘Surface control and vibration suppression of a large millimeter-wave telescope,’’ Smith and Parziale describe active techniques to improve telescope performance through active reduction of settling times in adaptive elements. Two papers by Furber and Jordan then follow that are focused toward the optimal design of wavefront sensors for adaptive optical systems, the first analyzing controllability and observability issues and the second dealing with optimization of subaperture locations.

We next turn to one of the enabling technologies for smart structures, advanced sensing. In the paper ‘‘Temperature-insensitive and strain-insensitive long-period grating sensors for smart structures’’ by Bhatia et al., a technique is described whereby a long-period Bragg grating in an optical fiber can be made sensitive to temperature but not strain, or sensitive to strain but not temperature. In the paper by Staszewski et al. that follows, we find the application of wavelet decomposition and fiber optic sensing to the problem of detecting hidden damage in composite smart structures.

The final two papers deal with smart civil structures, something of current interest in light of the state of civil infrastructure today. The paper ‘‘Interstory drift monitoring in smart buildings using laser crosshair projection’’ by Bennett and Batroney describes a straightforward and practical optical technique that could be applied to active structural control systems for buildings in areas susceptible to extreme loading conditions such as very high winds or earthquakes. The final paper by Udd et al. describes the use of fiber optic Bragg grating sensors to measure strain in large cylindrical composite structures.

This work represents one of the first uses of fiber optic sensors of this type on such large structures.

The field of smart structures is one of the most challenging and exciting areas to be involved in today. The highly interdisciplinary nature of this new field of endeavor, located at the intersection of a number of different disciplines, has room for significant contributions at all levels of experience, since it is new to all. In particular, the contributions of optical engineering are critical to the further advancement of the field. The search to create new structures that cost less than their passive counterparts and yet perform better offers a wonderful opportunity for students to participate at the beginning of a new field while letting experts grow beyond the boundaries of their established disciplines. The papers in this special section represent only a very small portion of research on smart structures, and I encourage you to further explore this new area of activity.

**William B. Spillman, Jr.,** received the AB degree in math/physics from Brown University in 1968 and the MS and PhD degrees in experimental solid state physics from Northeastern University in 1972 and 1977, respectively. Currently he is chief scientist at BFGoodrich Aerospace Aircraft Integrated Systems and an adjunct professor of physics at the University of Vermont. During his career, he has conducted research in the areas of low-temperature/high-pressure physics of crystals, fiber optic sensors, fiber optic switching devices, integrated optics, ultrasonic sensing, and smart structures. He has been involved in smart structures research since the mid-1980s. He is the author or coauthor of more than 100 technical papers, a number of book chapters, and two video short courses. He also holds 33 patents. His current research activities are focused around the development of very long gauge length sensors with antenna gain, smart structures, and automated sensor system design optimization using evolutionary computational techniques.