

ASNT Research Award for Sustained Excellence
Wednesday 20 March 2013
8:00-8:45 am

The Quest for Nondestructive Materials Characterization

Richard H. Bossi, Ph.D.
Senior Technical Fellow
Boeing Research & Technology



Nondestructive Testing/Inspection (NDT/I) has been concerned with the quality of products primarily by the detection and sizing of feature indications and comparing them to specification standards. This has served industry very well to identify defective products for disposition. However, the NDT/I methods are based on laws of physics that provide measures of basic materials properties. Nondestructive Evaluation (NDE) and Nondestructive Characterization (NDC) are terms that have been used to emphasize the use of the nondestructive measurement techniques for quantitative interpretation leading to fundamental property measurements conditions, material state assessment and fitness for service evaluation of products. NDE in its various methods is able measure such parameters as density, conductivity, attenuation, velocity, stiffness and thermal diffusivity to name a few. Over the years, considerable work has been performed to extract from the NDE measurements the characterization of the state of a material or product form that can move the fundamental nondestructive methodology from one of defect catching to process control of the material state condition.

Richard H. Bossi is the Senior Technical Fellow for Nondestructive Evaluation (NDE) and Materials Characterization at Boeing Research & Technology in Seattle, Washington. He received his Bachelor's degree from Seattle University in 1971 and his PhD from Oregon State University in 1977. Dick has over 40 years experience in the NDE field. Following graduate school he spent one year at Centre d'Etudes Nucleaires in Grenoble France, five years at Lawrence Livermore National Laboratory and four years at Sigma Research before joining The Boeing Company in 1987. He has worked on a variety of military and commercial aerospace programs using NDE technologies including radiography, computed tomography, ultrasonics, electromagnetics and data fusion. Dr. Bossi has been the author/co-author of over 150 publications/presentations and twenty patents. He is a Technical Fellow of the American Society for Nondestructive Testing, Technical Editor for *Materials Evaluation* and Chairman of the ASNT Handbook Committee. His current research is in the application NDE technology for material properties and bond strength measurement.

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MWM-Arrays & HyperLattices - History and Accomplishments

Neil Goldfine, Ph.D.

President, JENTEK Sensors, Inc.



In the mid-1980s, at the MIT Laboratory for Electromagnetics and Electronic Systems, Development of the MWM[®]-Array technology and the HyperLattice[™] inverse methods began. The MWM and MWM-Array are magnetoquasistatic (MQS) sensors that operate as eddy current sensors when interrogating conducting media, but also can measure properties of non-conducting magnetic media (when there are no eddy currents induced). The key innovation of the MWM and MWM-Arrays is the use of simple lines and rectangles for the drive and sense “windings” to enable accurate physics-based modeling of the magnetic field interactions with a material under test. HyperLattice-based inverse methods use rapid searches of multidimensional databases to estimate multiple properties from sensor data. These HyperLattices (or sensor response databases) are precomputed using physics-based models of the sensor’s magnetic field interactions with a material under test. The third required component required to deliver a complete NDT solution is a wide bandwidth (1 Hz – 20 MHz) fully parallel impedance instrument that can rapidly and simultaneously acquire data from numerous channels in parallel for multiple frequencies.

Implemented on the Space Shuttle leading edge RCC, U.S. Navy engine disks and blades, land-based turbine components, commercial engine components and in manufacturing quality assessment, the MWM-Array is now a standard military and commercial practice. This presentation will review some of the accomplishments over the last few decades beginning with the original MIT Research, under the late Prof. James R. Melcher, and continuing at JENTEK Sensors, Inc. after 1992. Accomplishments include “air calibration” as a method of eliminating the need for defect standards for calibration of eddy current instruments (a DoD, NASA and OEM standard practice, the “technical aspects” of the method being FAA approved for specific ongoing commercial engine component inspections); characterization of thickness and porosity for thermal spray coatings (using methods described in ASTM STD E2338-04); hundreds of successful coupon tests for permanently installed MWM-Rosettes for surface and buried crack detection at fasteners; carbon fiber and reinforced carbon-carbon composite (RCC) inspection for impact and thermal damage; and most recently, detection of external and internal corrosion in relatively thick steel pipe walls (e.g. 0.4 in. wall) through over 2 in. of insulation and a metallic weather jacket, using very low frequency eddy current arrays, called MR-MWM-Arrays.

This presentation will provide a brief history of the MWM-Array and HyperLattice methods with case studies and descriptions of ongoing efforts. These technologies are described in over 50 issued U.S. patents and have been the subject of numerous papers and presentations, beginning with the first public presentation at the 1992 ASNT Fall Conference and the first paper published in the March 1993 issue of *Materials Evaluation* (Vol. 51, No. 3), titled “Magnetometers for Improved Materials Characterization in Aerospace Applications.”

Dr. Neil Goldfine founded JENTEK Sensors, Inc. in 1992, and has been President and Chief Engineer since that time. He has been a Research Affiliate in the MIT electrical engineering department for two decades. He completed his Ph.D. at MIT in 1990 and has Bachelors degrees in both Electrical Engineering and Mechanical Engineering from the University of Pennsylvania. Dr. Goldfine has over 50 patents in NDT and related fields, and has authored numerous technical papers.