Short Course on October 7, 2012

Title: **Novel Measurement Techniques in Medicine and NDE Based on Sound Field Simulation**

Instructors: **Elfgard Kühnicke**, TU Dresden, **Michael Lenz**, TU Dresden, **Bernd Köhler**, FhG IZfP, Dresden

Course Description

With the help of adequate sound field simulations, it is not only possible to develop customized ultrasonic transducers, but also to derive new ultrasonic measurement methods that exploit the sound field characteristics of the specific set-up. This lecture intends to increase awareness and give proof of the fact that the reflected sound waves comprise much more information than the time of flight between ultrasonic transducer and reflector.

Special attention will be given to the following topics:

- Development of application-specific ultrasonic transducers
  Focusing transducers, single element transducers, transmit-receive-transducers, arrays with line elements, annular arrays, characterization of arrays with sound field measurements, optimization of array excitation and measurement set-up

- Development of novel measurement techniques for NDT, process measurement technology and medical diagnostics by exploitation of the information comprised in the reflected sound field (signal information on the different array elements, variation of the sending sound field by focus variation)
  Examples: Non-invasive non-scanning method for curvature measurements, non-invasive method for combined measurement of distances and sound velocity (not using the bottom-echo)

- Improvement of resolution by exploiting the directivity of the reflected sound (lateral direction) and by separating the interfering signals in multi-layered structures as often needed in ultrasonic microscopy with interface layers being smaller than the signal length (axial direction)

Complementary to numerical calculations of sound fields in fluids or elastodynamic wave fields in solids, the precise and non-disturbing measurement of these fields gives additional information about the system in question. The direct comparison of measurement and simulation of the same situation is often important. A very elegant method for non-disturbing measurements is the contactless laser vibrometric detection, which will be illustrated by the following examples:

- Wave propagation in strongly heterogeneous materials, as for example concrete: by direct comparison of modeling and sound field measurements, a strong contribution of cracks and delaminations to the ultrasound attenuation is predicted.

- Wave propagation in strongly anisotropic inhomogeneous materials: austenitic and bimetallic welds in thick walled components are examples of high industrial importance; it is very interesting that the grain structure at the measurement cross section can be visualized with the elastodynamic field measurement data.

- Numerical simulation of sound field generation and propagation is essential in the understanding and interpretation of measured effects such as: acoustic waves generated by high energy ion beam cancer therapy or laser excitation of acoustic pulses in ophthalmology for presbyopia treatment.
- Interferometric measurements of the full displacement vector at the surface of solids are possible; this gives access to new measurement quantities like the excentricity of guided waves. Also, the plate waves (Lamb waves) used in Structural Health Monitoring applications and the Lamb wave defect interaction can be understood much better.

Elfgard Kühnicke received her Diplom degree in physics from the University of Leipzig. From 1978 to 1986, she worked at the Technical University of Zittau in the field of Acoustic Emission, and received her Ph.D. in physics in 1985 by the Otto-von-Guericke-University of Magdeburg. From 1988 to 1991, she worked at the Academy of Sciences of the GDR in the field of ultrasonics. In 1993 she joined the Institute of Technical Acoustics at the Dresden University of Technology, where she received the postdoctoral lecture qualification in 2001. Since 2008, she has been a professor of ultrasonics at the Technical University of Dresden. Her research interests include sensor design and modelling of ultrasonics fields for medicine and NDT.

Michael Lenz received his Diplom degree in electrical engineering (specialization in acoustics) from the Technical University of Dresden in 2003. After a short engagement as a test engineer in the semiconductor industry, he returned to the University of Dresden as a Ph.D. student in the field of ultrasonics in 2005. His research interests include non-scanning curvature measurements with ultrasound, locally resolved sound velocity measurements and Doppler techniques.

Bernd Köhler earned his Diplom degree in physics from the Technical University of Dresden in 1977. From 1977 to 1984, he worked in the field of Theoretical Physics at the Technical University, from which he also received his Ph.D.. From 1984 to 1991, he was employed at the Research Centre Rossendorf and worked on Nondestrictive Testing for NPP by ultrasonic methods. He was responsible for the modelling of ultrasonic probe behaviour. Since 1991, he has been with the Fraunhofer Institute for Non-destructive Testing, Dresden branch and holds the position of department head since 2004. His research fields cover experimental methods for ultrasound (contactless and highly resolved sound field measurements), combined methods (electrode beam excited ultrasound = scanning electron acoustic microscopy and ion acoustics etc.), high frequency ultrasound (acoustic microscopy), and micro- and nano-NDE. He received the Berthold award of the German Society for Non-destructive Testing (DGZfP) in 1992.

Conference website: http://ewh.ieee.org/conf/ius_2012

Sponsored by the IEEE Ultrasonics, Ferroelectrics & Frequency Control Society

IEEE ULTRASONICS, FERROELECTRICS, AND FREQUENCY CONTROL SOCIETY