Course Title: Ultrasonic NDE and industrial process diagnostics at high temperatures

Jean-Pierre Monchalin, Industrial Materials Institute, National Research Council Canada, Boucherville, Quebec, Canada

Cheng-Kuei Jen, Industrial Materials Institute, National Research Council Canada, Boucherville, Quebec, Canada

Course description: This course provides an introduction of two types of ultrasonic techniques to perform high temperature NDE and industrial process diagnostics. The basic principles of the first technique which is a non-contact laser generation and laser detection of ultrasound method will be explained. Pulsed lasers of various wavelengths are used for the generation and confocal Fabry-Perot or two-wave mixing photo-refractive type interferometers for the detection of ultrasound. On-line evaluations of the eccentricity and grain size of the extruded seamless steel tubes, the texture, thickness and plastic strain ratio of steel plates simultaneously and microstructures during thermomechanical simulations, and NDE of aerospace and power plant parts will be illustrated. The second technique involving a sol-gel spray piezoelectric thick film technology to fabricate integrated and flexible ultrasonic transducers will be presented. Their merits that (a) are capable to operate up to more than 800°C, (b) are able to be attached, coated, bonded or brazed onto curved metallic or composite material surfaces on-site, (c) can generate and receive longitudinal, shear, Lamb and surface acoustic waves, (d) can be made into array configurations, and (e) have broad bandwidth will be demonstrated. Applications of these transducers for NDE of pipes, aerospace metallic and composite parts, and real-time non-invasive diagnostics of industrial polymer extrusion, injection melding and molten metal processing at high temperatures will be given.

Jean-Pierre Monchalin received a diploma in optical engineering in Paris in 1968 and the M.S. and Ph.D. degrees in lasers and optics from the Massachusetts Institute of Technology, Cambridge, in 1971 and 1976. He is presently Principal Research Officer at the Industrial Materials Institute of the National Research Council of Canada in Boucherville, Québec, Canada and head of the Materials and Processes Diagnostics group at the Institute. His doctoral work at MIT consisted of very accurate interferometric measurement in the infrared which led to a new value for the speed of light. He was then employed by École Polytechnique in Montréal and worked on chemical laser development, photoacoustic techniques and, in particular, on their application to the spectroscopy of powders. He has been involved with ultrasonic nondestructive evaluation since 1982. He is presently leading development work in laser and optical techniques to generate and detect ultrasound for industrial applications. He has published numerous papers and is the holder of sixteen patents in this field. He is a member of the Optical Society of America and of SPIE.

Cheng-Kuei Jen is a principal research officer at the Industrial Materials Institute, National Research Council of Canada at Boucherville, Quebec, Canada. He has been an adjunct professor at McGill University since 1983. His recently R&D activities have been devoted to two main areas. One is on the integration of miniature piezoelectric/ultrasonic sensors and arrays for diagnostic health monitoring and non-destructive testing of aerospace structures, power plants, engines and pipes. The novelties of the developed sensors are on-site fabrication including onto curved surfaces, flexible, high temperature (>800°C) and broad bandwidth operation capability. Another R&D direction is real-time, non-invasive and non-destructive diagnostics of industrial materials processes, material characterization and nondestructive evaluation techniques using ultrasound. Several sensors, techniques and systems have been developed, patented, and licensed. The applications include polymer extrusion, polymer injection molding, molten zinc, aluminum and magnesium die casting and copper tube extrusion. Dr. Jen was an associate editor for the IEEE Transaction on Ultrasonics, Ferroelectrics and Frequency Control between 1994 and 2003. In the past thirty years he has co-authored more than one hundred and thirty refereed journal papers, three book chapters and eleven U.S. patents in the field of ultrasound.