SAND2012-9773C

Exceptional service in the national interest

Sandia National Laboratories

Complex Strain Field Monitoring Via Electrical Impedance Tomography

Bryan R. Loyola[1,3], Valeria La Saponara[1], Kenneth J. Loh[2], Greg O'Bryan[3], Jack L. Skinner[3], Timothy Briggs[3]

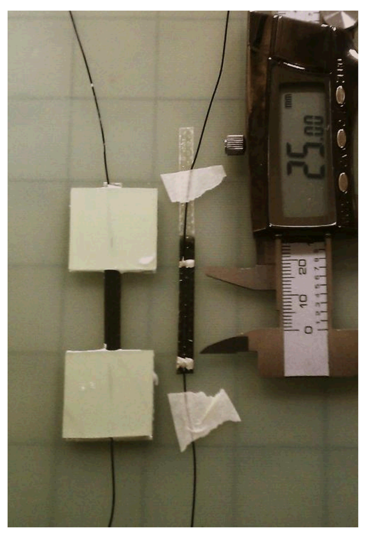
[1]Mechanical and Aerospace Engineering, University of California, Davis
[2]Civil and Environmental Engineering, University of California, Davis
[3]Sandia National Laboratories, Livermore, CA

Abstract

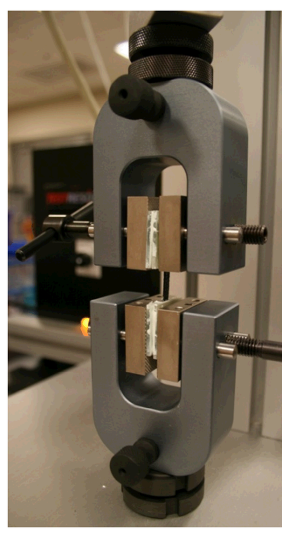
In this study, we introduce the use of electrical impedance tomography for distributed electrical conductivity monitoring of embedded multi-walled carbon nanotube (MWNT)–latex films. In a previous study, the electrical conductivity response to applied strain has been characterized for these films, thus enabling distributed strain sensing capabilities. For direct fiber monitoring in glass fiber-reinforced polymer (GFRP) composites, the MWNT-latex films are deposited upon unidirectional glass fiber mats, which are laid up into a GFRP composite panel. A custom-built indentation fixture subjects the specimens to a complex loading distribution, yielding a similarly complex strain distribution. Monitoring the strain distribution from increased loading is accomplished via electrical impedance tomography, which captures the change in electrical conductivity across the embedded MWNT-latex film, thus capturing the increased strain response of the specimen.

MWNT-PVDF Strain Sensitivity

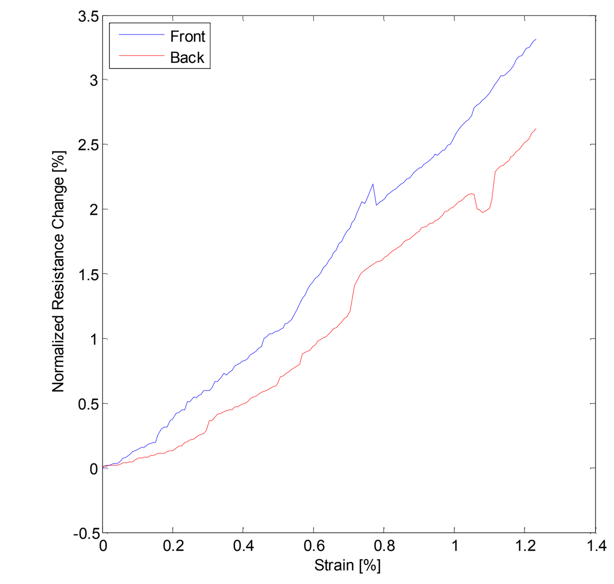
A MWNT-PVDF latex film was developed and tested for strain sensitivity upon GFRP substrates. The specimens (shown to the right) were subjected to monotonically increasing uniaxial tensile loads using a load frame. The resistance across the gauge length of the specimen was monitored during the loading and is reported for films deposited on the front and back side of the substrates. The responses of these films indicated that more than one strain sensitivity regime is present. A spatially sensitive measurement method is desire to perform more than point-based measurements for complex strain patterns.



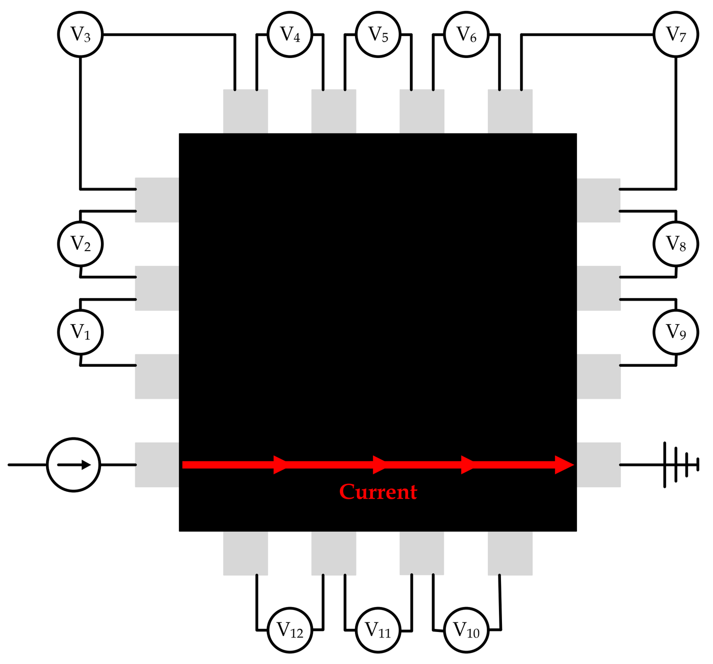
Fiber-coated specimen



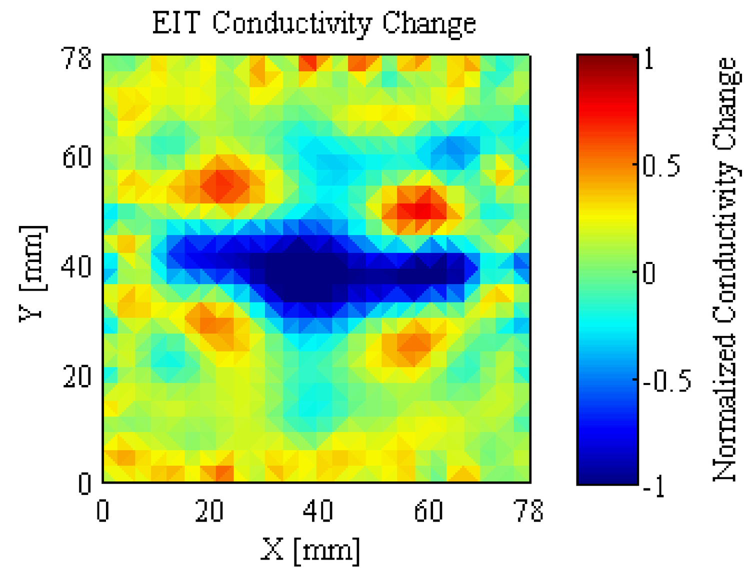
Thin film mounted in load frame



Resistance strain response



EIT Measurement Scheme



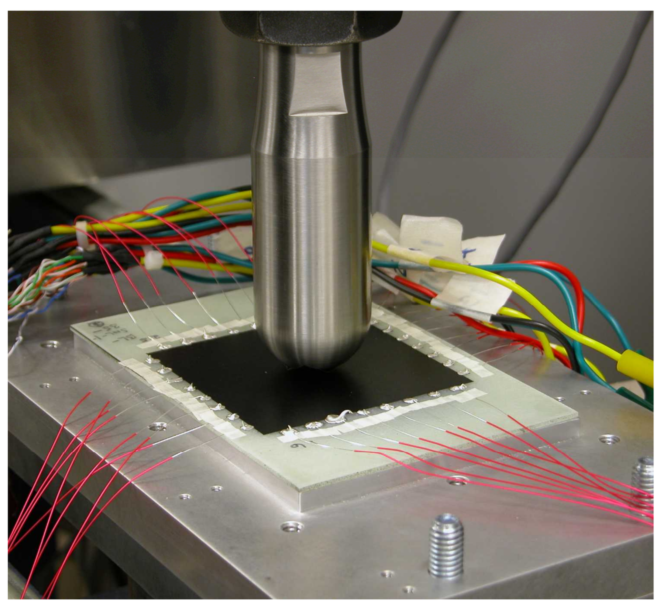
Cross conductivity pattern reconstruction

Electrical Impedance Tomography

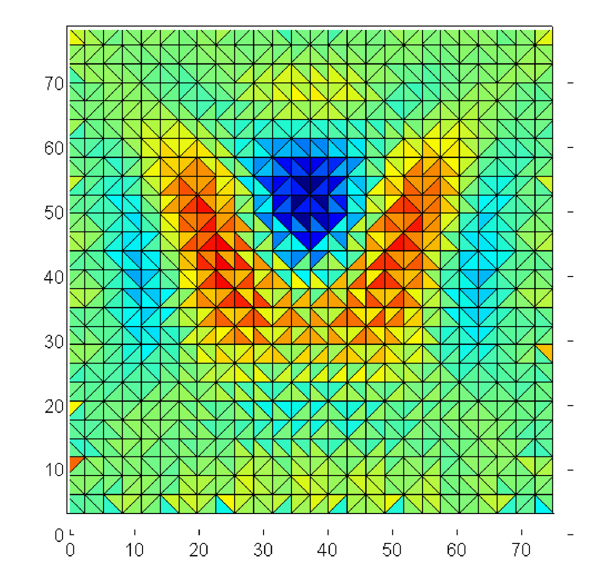
Electrical impedance tomography is an electrical measurement technique that can capture the spatially distributed conductivity of the applied MWNT-PVDF films. The technique works by bounding a conductive medium with electrodes, driving a current between two of the electrodes, and measuring the voltage at the remaining adjacent electrodes. These measurements are performed for many current injection patterns and are then applied to a linear EIT reconstruction algorithm. The resulting conductivity pattern is then determined, and an example of one is shown to the left.

Indentation EIT Response

To determine if EIT can capture the complex strain response from the MWNT-PVDF films applied to GFRP substrates, the specimens were indented using the setup to presented on the left. The indenter tup is hemispherical with a 1.5" diameter. EIT measurements were taken at 1 mm displacements of the indenter, up to 5 mm. The measured EIT response to a 2 mm indented state is presented to the right. Further work is being conducted to validate that this strain response is appropriate for these specimens under these boundary conditions.



Indentation Setup



EIT Response

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.
SAND No. 2011-XXXXP