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Far-Field Microwave Time Reversal Experiments for Imaging Disbonds in Metal-Composite Structures

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Composites are being increasingly used to replace metals, in several industries because of their light weight, corrosion resistance, and mechanical strength. In these structures involving metals and composites, adhesively bonded joints are preferred in contrast to conventional fasteners as they provide light weight designs, reduce stress concentrations. However, disbonds and delamination can compromise the integrity of the structure affecting their performance. Hence a robust and effective Non Destructive Evaluation (NDE) technique is required to accurately detect defects in composite materials. Microwave NDE is increasingly being used as an alternate method since it is well suited for lossless and low loss dielectric materials because electromagnetic waves can propagate and interact with them [1]. Since the scattered field depends on the dielectric properties of the material, the scattered data contains information related to geometry of the structure

Time Reversal focusing is based on the fact that when a wave solution is reversed in time and back-propagated it refocuses back at the source. Recent studies by Fink et. al. [2] have shown promising results by extending the concept of time reversal imaging to wideband electromagnetic waves. In the previous year, various simulation results and parametric studies were presented to demonstrate the feasibility of microwave time reversal to detect and characterize disbonds (Fig. 1) [3]. In this contribution, far field time reversal imaging experiments for such NDE applications will be presented. Far field measurements with an ultra-wideband excitation source (2-18 GHz) using a pulsed time domain laboratory setup are processed using a passive time reversal technique. Time reversed images show accurate detection of multiple defects in composite structures.

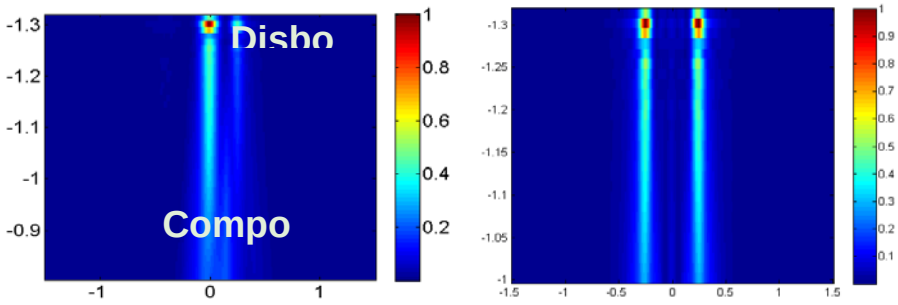

Figure 1. Simulation studies showing detection of single (left) and multiple disbonds (right) by microwave time reversal technique

Experiments are also performed to estimate the time reversed down-range and cross-range resolutions. The focusing resolution of the reconstructed image is studied particularly with regard to rapid inspection of large areas. Although preliminary testing is being done in microwave frequencies (2-18 GHz), the system can be easily scaled to millimetre or terahertz wave frequencies for increased imaging/detection resolution.

References:

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