Microwave Inverse Scattering Algorithm with Full-cavity Numerical Characterizations

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We present the results of microwave inverse scattering algorithm with full-cavity numerical characterizations. A conformal finite difference time domain (FDTD) method is used to efficiently and accurately model the antennas and the cavity, while serving as a wideband forward solver to calculate the scattered S-parameter during the inversion. A custom numerical Green's function with waveport source excitation is developed which directly links the measured scattered S-parameters with the material contrast we wish to image. The inversion is implemented with the Born iterative method (BIM) with regularized multi-parameter local optimization process. .

To efficiently model the antennas and imaging cavity, a conformal FDTD method which utilize the subcellular information of the Yee cell is implemented. This conformal FDTD technique allows a modeling resolution exceed the size of Yee cell. With a developed complimentary waveport excitation and S-parameter extraction method under the conformal FDTD framework, we are able to accurately compute the scattered S-parameter of different dielectric objects with the imaging cavity.

With the presence of the antenna and cavity in the imaging background, a numerical Green's function must be implemented to link the scattered field with the object contrast. Meanwhile, to apply the inversion algorithm with the experiments, two additional details need to be considered: 1.The scattered field is measured in the form of the scattered S-parameter with the vector network analyzer (VNA); 2.The antennas are excited with a waveport source at the coaxial feed other than a simple point source. Thus, we developed a custom numerical Green's function for S-parameter measurement with waveport excitation and integrated it into the inversion algorithm. The comparison between the scattered S-parameter measured by the VNA and estimated by the custom numerical Green's function will be demonstrated.

The imaging cavity is a cuboid consisting of 4 panels. Each panel has 9 dual-band tapered patch antennas operating at 915MHz and 2.1GHz. Among the 36 antennas, 18 of them will be used as transmitter and the rest 18 as receivers. The inversion algorithm is based on the Born iterative method (BIM) with a regularized multi-parameter local optimization process. With the integration of the BIM and the custom numerical Green's function, we were able to form images with the measured scattered S-parameter. Imaging results of several objects will be presented.