Effects of Surface Curvature on SAR Image Formation

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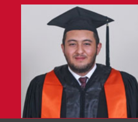

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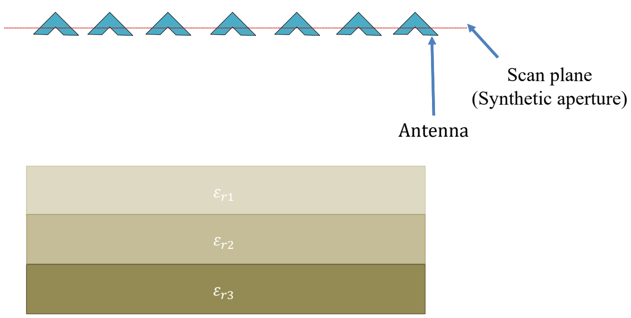
Objective: To develop synthetic aperture radar (SAR) imaging techniques to image subsurface features in non-planar multi-layer structures

Background

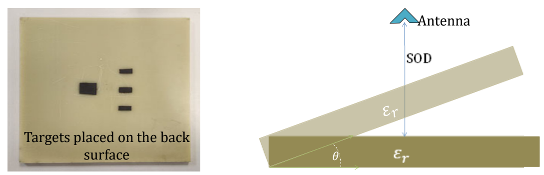
- Microwave SAR imaging is used for imaging non-conductive composites as well as detecting and characterizing the orientation of cracks on metal surfaces.
- SAR imaging algorithms can compensate for the signal propagation through a multi-layered dielectric structure, and the associated refractions, signal magnitude and phase change, producing a focused high-resolution 3D images.



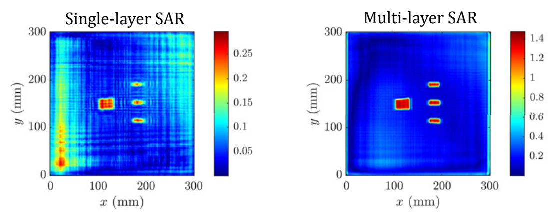
- Currently used SAR algorithms assume that the synthetic aperture and the surfaces of the multi-layered composites are flat and parallel to each other.
- However, there are many applications where the scanned sample can have generally non-planar geometries.
- These non-planar geometries can result in distorted SAR images due to non-uniform refractions, as the incidence angles change along the surfaces of the interfaces.

Experimental Results

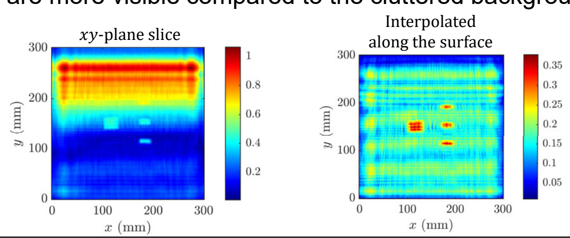
- A square Garolite (FR-4) slab with multiple scatterer targets on its back surface is used.
- The sample was scanned at multiple tilt angles using a Ka-band (26.5 – 40 GHz) open-ended waveguide.



- The strongly scattering targets can be seen without multi-layer SAR processing, but not fully focused. Using the multi-layer SAR algorithm, the image in improved.

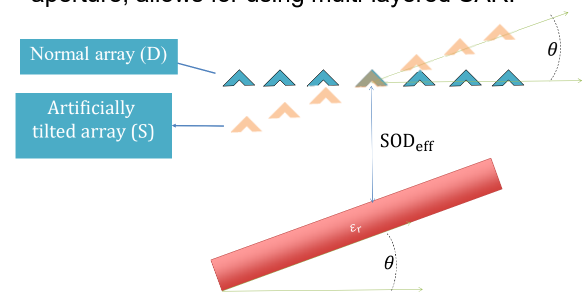


- Multi-layer SAR algorithm cannot be used when the slab is not flat. Producing an xy-plane image, does not show clear indications of the target.
- Interpolating the SAR image along the plane containing the bottom of the slab, produces target indications that are more visible compared to the cluttered background.



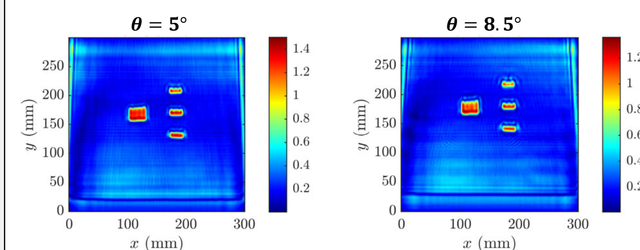
Correction

- Compensating for the distance variations by moving the phase reference planes of the antennas on the synthetic aperture, allows for using multi-layered SAR.



- The collected data is multiplied by a correction factor that depends on the surface geometry.

$$S(x,y,f) = D(x,y,f)e^{-j2k_r(f)\left(\frac{L}{2}-y\right)\tan(\theta)}$$



Conclusion

- The proposed solution could be used to compensate for the non-planar interfaces if the geometry of the interface is already known.
- A full vector wave backpropagation (using appropriate Green's function) can be used to obtain images with a higher quality of the indications of the targets.

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