Electromagnetic Strategies for Locatable Plastic Pipe

U.S. Department of Transportation
Pipeline and Hazardous Materials
Safety Administration

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Main Objective

Plastic utilities pipes are difficult to locate with traditional detection systems. This research seeks to develop polyethylene (PE) antennas that could easily be molded to polyethylene pipe and allow the pipe to be easily detected with Ground Penetrating Radar (GPR). These antennas must be both durable enough to survive pipe transport and installation and electrically conductive enough that they can be detected with commercial radar equipment.

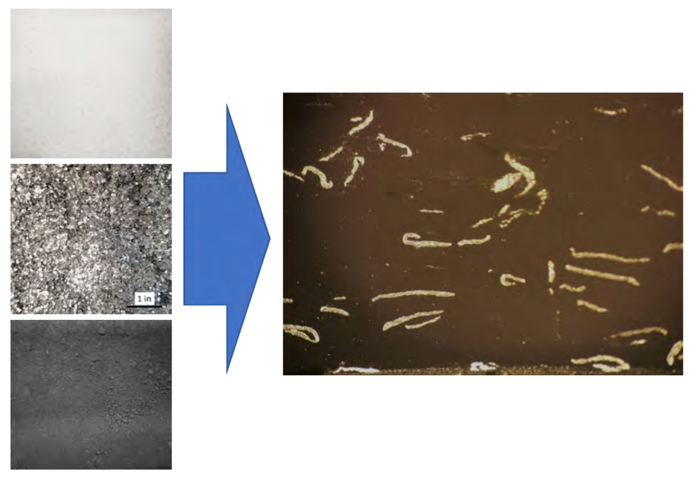

Figure 1: Aluminum flake and carbon black are compounded into PE to create an electrically conductive material.

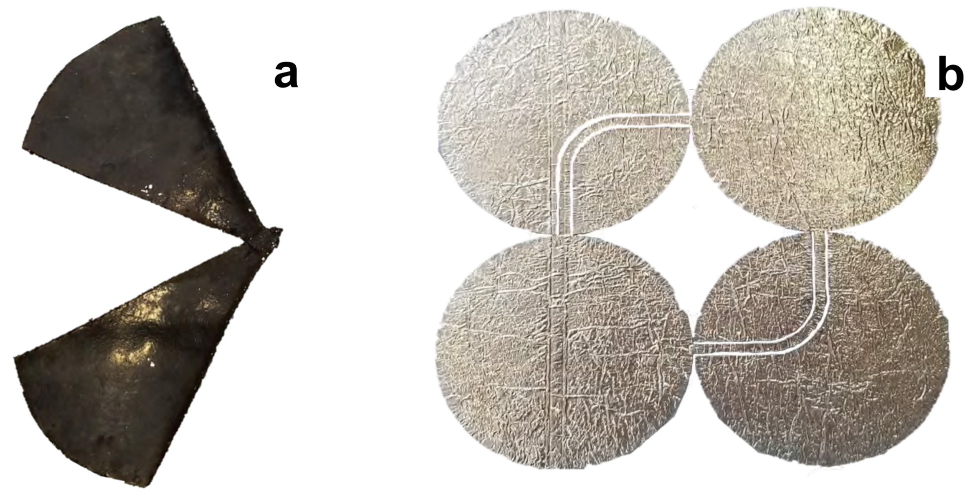

Figure 2: (a) A bowtie antenna made of conductive polyethylene and (b) a cross polarization antenna made from steel foil.

Project Approach

- Strains on PE pipe were measured using digital image correlation (DIC).
- Mechanical and electrical properties of the doped PE material were measured to ensure the antennas would function as intended and survive use.
- Antenna designs were simulated and tested to determine an antenna that could be easily manufactured but was still detectable.
- Doped PE antennas were tested against metal antennas.
- Antennas were tested in an in-ground polyethylene pipe.

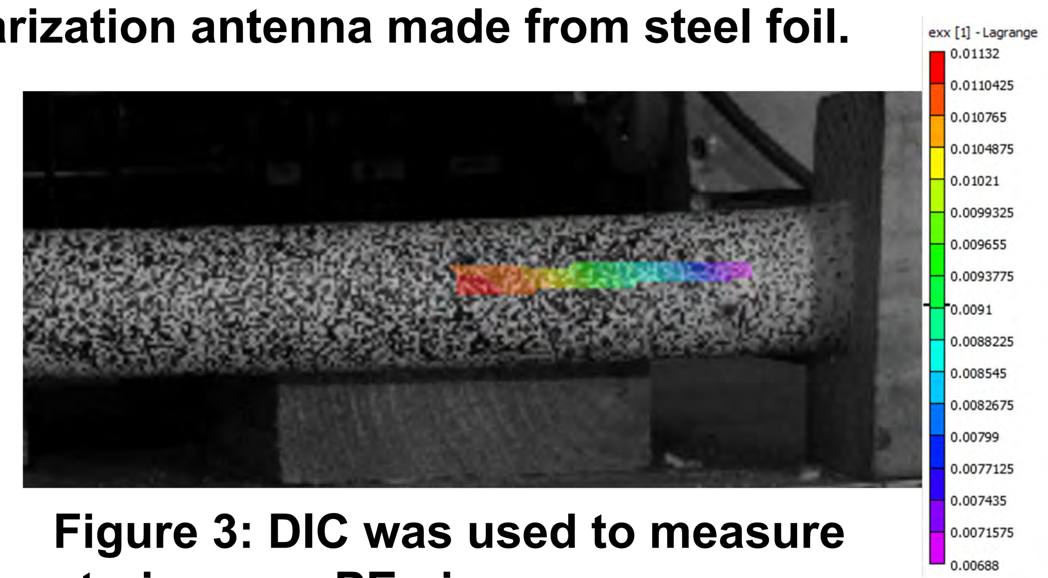

Figure 3: DIC was used to measure strains on a PE pipe.

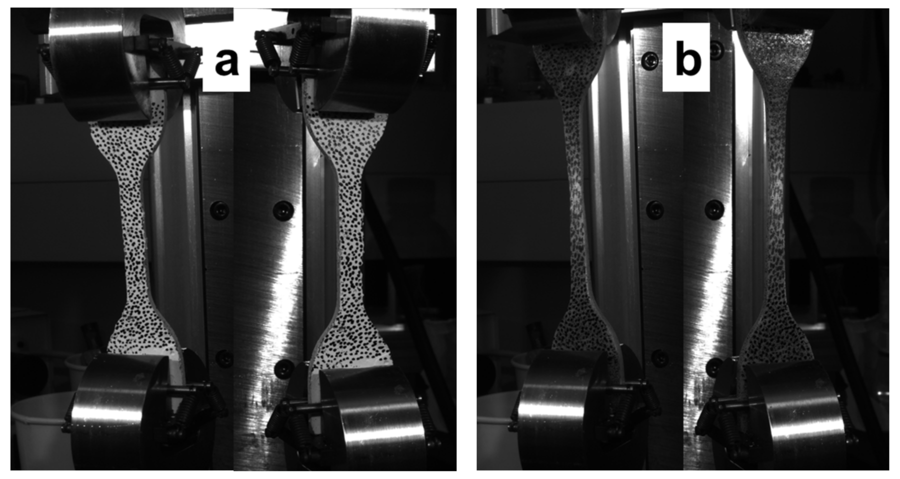

Figure 4: (a) DIC of doped PE specimens (b) DIC of neat PE specimens

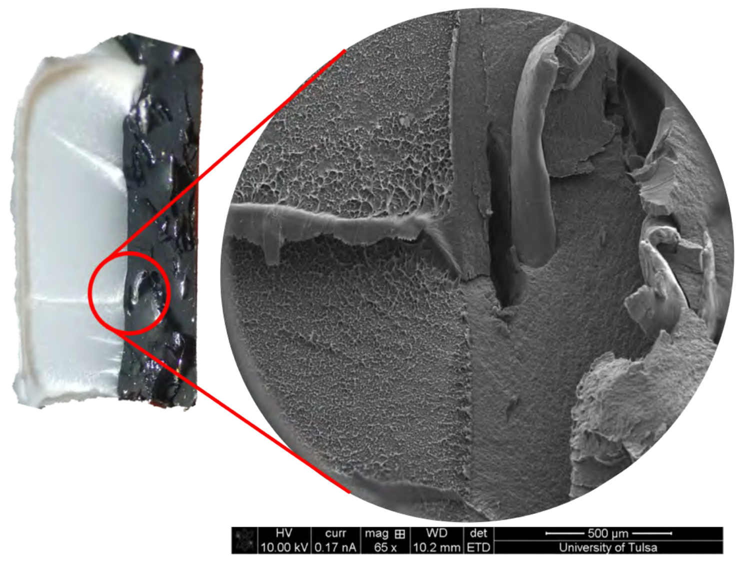

Figure 5: Scanning Electron Microscope image of a cross section of a bilayer PE specimen

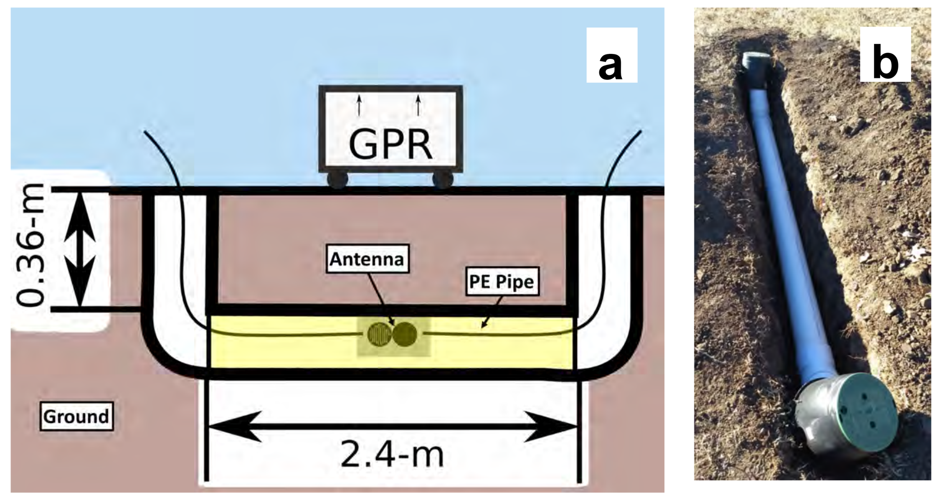

Figure 6: (a) Schematic of in-ground pipe testing setup (b) PE pipe used for testing.

Results

- Doped PE antennas were detected with GPR.
- PE pipe with an antenna was located using GPR.
- The radar signal of the antenna on the pipe resonated.
- Measured strains on pipe were higher than predicted by strain model.
- Doped PE exhibited more brittle behavior than neat PE.
- Doped PE antennas would likely survive the long term strains on the pipe, but would likely show damage at the tightest allowable curvatures.

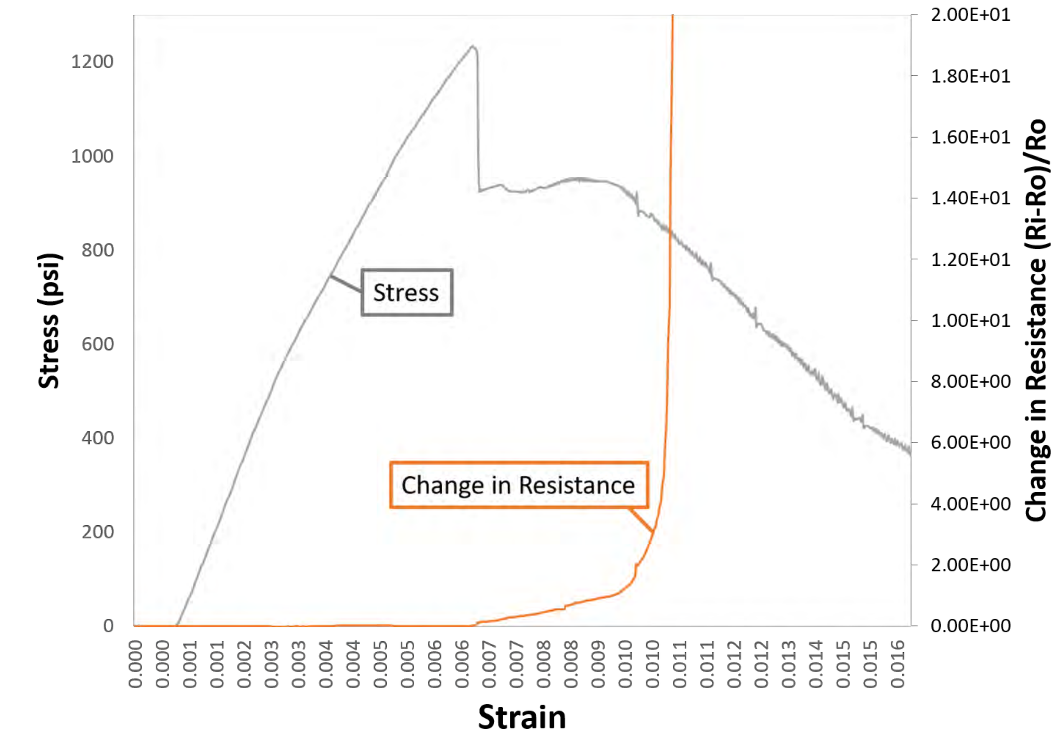

Figure 7: Stress and change in resistance vs strain for bilayer doped and neat polyethylene specimens

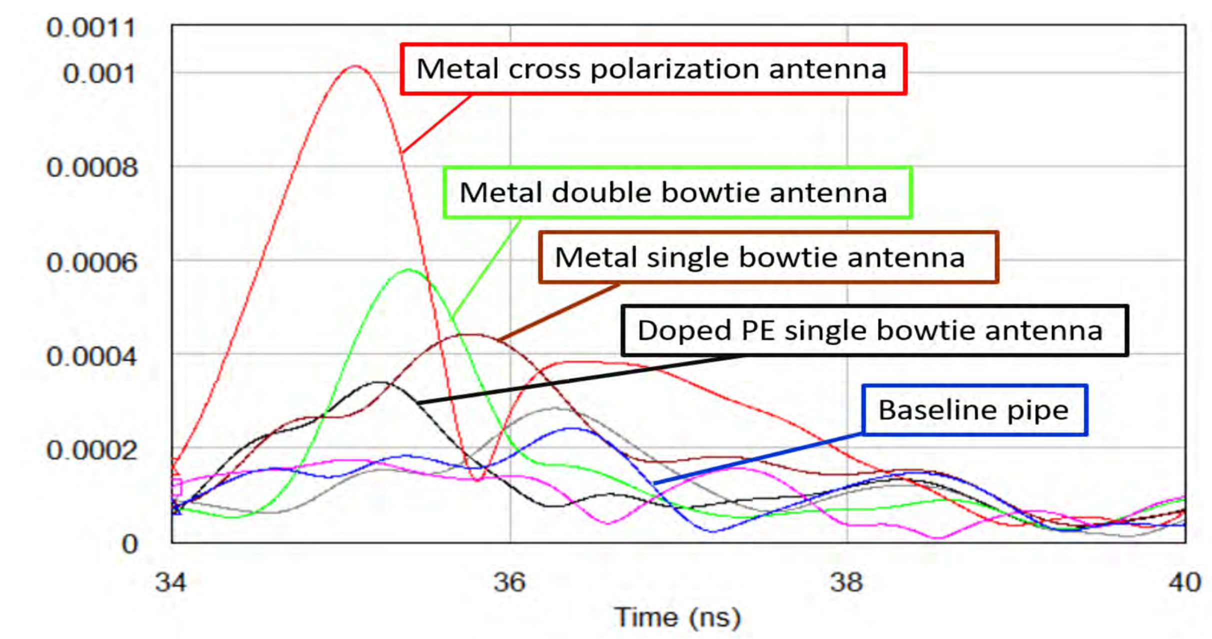

Figure 8: Response of metal and conductive PE antennas to GPR

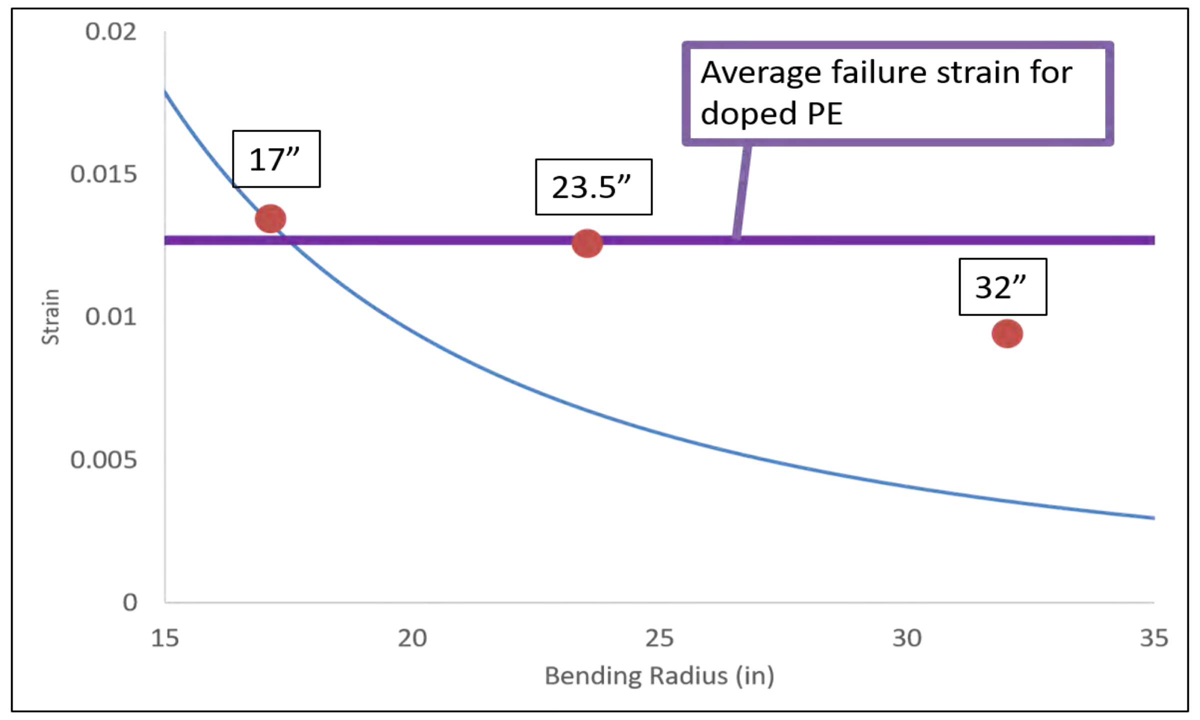

Figure 9: Measured strain on a 1" pipe in bending and the model prediction for strain.

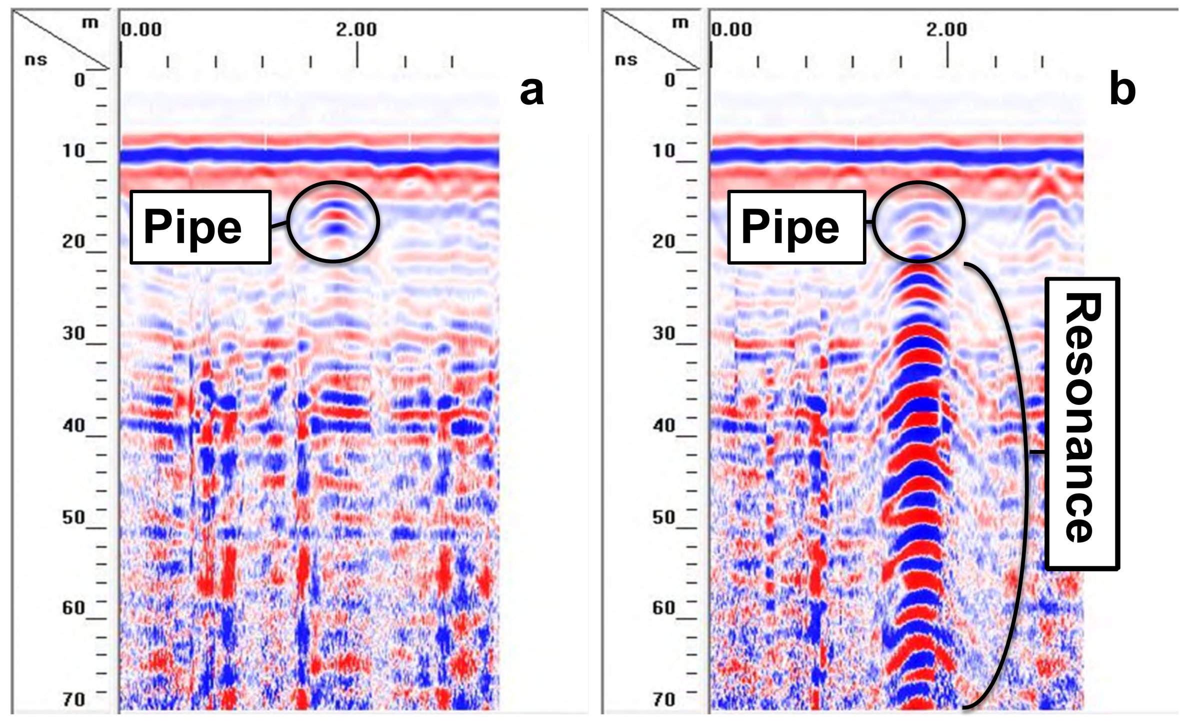

Figure 10: GPR B-scans of (a) PE pipe and (b) the same PE pipe with a cross polarization antenna.

Acknowledgments

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