ADDITIVE MANUFACTURING OF MULTI-MATERIAL GRADED DIELECTRICS

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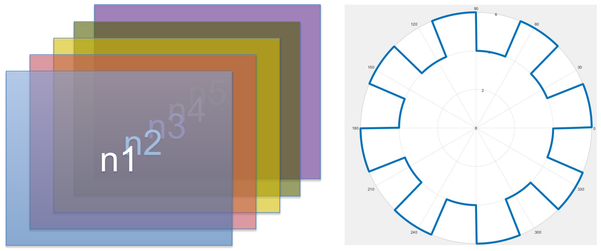
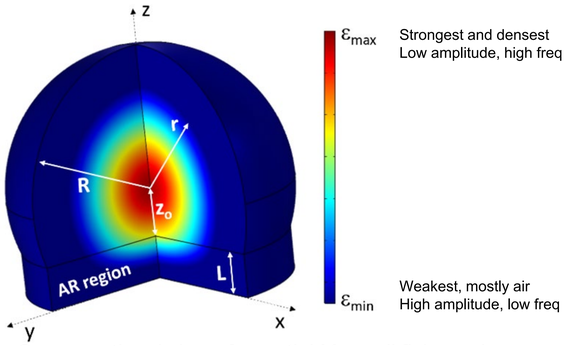
Background + Justification

- Gradient index (GRIN) devices are devices with refractive indices that vary spatially.
- Existing designs are prohibitively expensive because they use multiple discrete layers of material.

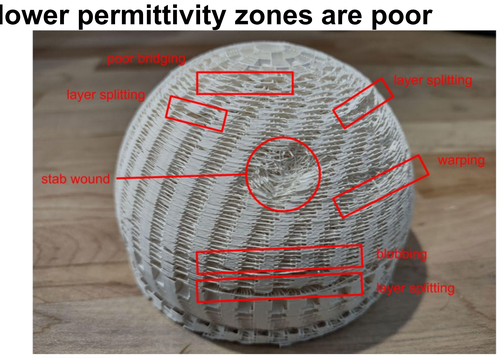


- Modifying the amplitude and frequency of a space filling square wave can create a gradient of permittivity with one material.

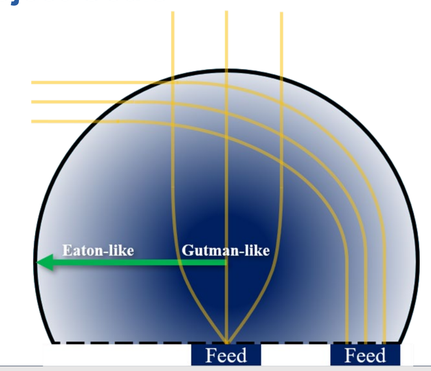


Cross-sectional view of a partial Maxwell fish-eye lens.

- Also, high performance lenses require a large permittivity range, difficult with just one material.
- **Print quality and structural strength of lower permittivity zones are poor**



Project Goals



1. **Replicate the properties of a partial Maxwell fish-eye (PMFE) lenses in the 4-40 GHz band**
   a. 90° passive beam steering on edges
   b. Focusing lens in center
   c. High-gain, ultra-wide (180°) angle

1. **Multi-material fabrication process**
   a. Integrate new printer and filament swap system
   b. Measure material properties
   c. program .GCODE command generation

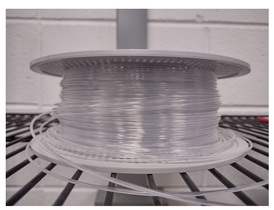
Printer Selection

Bambu Lab X1C

- 20 m/s^2 acceleration
- automatic bed leveling
- auto flow calibration
- LIDAR print quality detection
- Heated enclosure
- Up to 16 materials in one print

*Features ensure that quality is **consistent** across prints*

Material Calibration



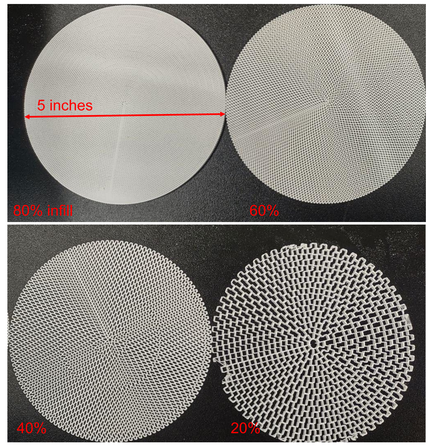
Polycarbonate

- high impact resistance
- extremely durable
- lower max permittivity
- dk ~2.8

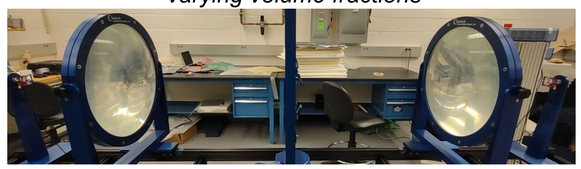
Preperm ABS 550

- brittle
- expensive
- higher max permittivity
- dk ~5.5

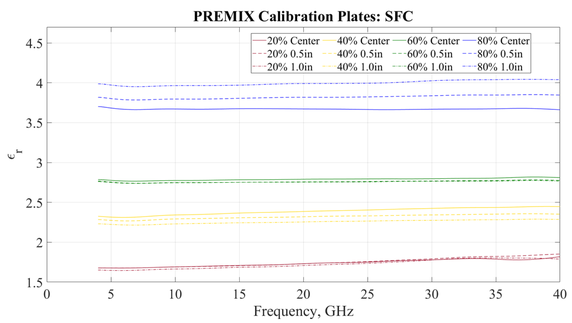
Material Calibration Cont.

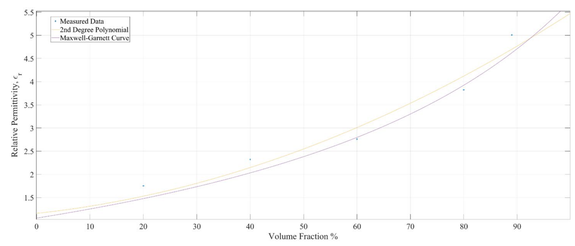


Printed 5 inch homogenous calibration plates at varying volume fractions



Permittivity measured for R = 0 in, 0.5 in, 1 in on free space focused beam system

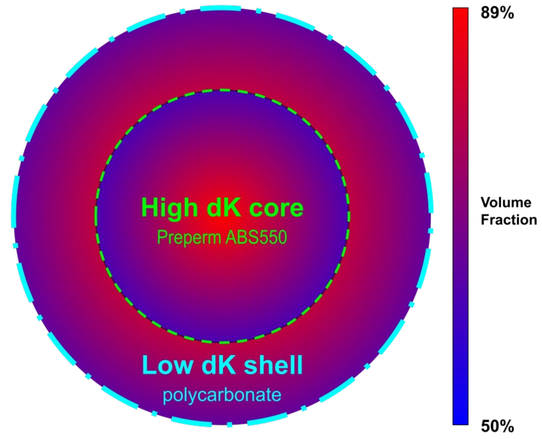




Curve and data **mismatch** suggests **difference between** real volume fraction and theoretical volume fraction

Further print calibration is necessary prior to full lens print

Future Objectives



FDM printable bi-material PMFE lens

- Work is underway to address the disparity in volume fraction, and to print a full single material lens on the X1C
- Implement filament switch subroutine into .GCODE generator, as well as prime/flush towers
- Print and test a complete multi-material lens
- Evaluate beam steering and focusing capabilities of multi-material lenses; test strength and durability
- Measure effectiveness of other SFCs, especially concentric circles and variable angle triangles, experiment with higher dK plastic filaments (dk 10+)

Acknowledgements

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