Spatially- Variant Self-Collimating Photonic Crystal

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INTRODUCTION

The EM Lab has designed and manufactured a spatially-variant all-dielectric self-collimating photonic crystal. The device was designed using their novel synthesis tool for spatially-variant lattices. The device demonstrates a novel concept for spatial control of waves in 3D systems using all-dielectric structures that avoid losses encountered when using metals.

BENEFITS AND APPLICATIONS

- All-dielectric design
- Suitable for high power microwaves and photonics
- Extremely low loss
- Highly compact devices using even low dielectric constant materials (i.e., $\varepsilon_r < 3.0$)
- Robust to material properties.

STEP 1: DESIGN AND OPTIMIZE A SELF-COLLIMATING UNIT CELL

A simple cubic unit cell is calculated as the superposition of three planar gratings.

Self-collimation is predicted and analyzed using the concept of isofrequency contours.

The lattice constant is adjusted based on fill fraction to operate the lattice at a desired frequency.

STEP 2: GENERATE SPATIALLY VARIANT LATTICE

Synthesis Tool
- Tool takes in input:
  1. Size of lattice: 22x22 unit cells.
  2. Orientation data: Azimuthal function with buffer regions.

Resulting Lattice
- The resulting lattice is a smooth, continuous 90° bend which can be stacked upon manufacturing.

STEP 3: SIMULATE LATTICE AND BEND RADIUS

To determine the size of the lattice, a series of simulations were performed with varying number of unit cells and bend radii. Good performance was observed with just 12×12 unit cells, but the final device was made with 22×22.

STEP 4: MANUFACTURE AND TEST THE DEVICE

Measured Bandwidth:
- 14.8 GHz to 16.8 GHz
- 6.5% fractional bandwidth

Measured results confirm operation.

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