Multilayered Polymeric Materials for Terahertz Applications

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Goal
In this project we plan to design, fabricate, and charac-
terize multilayered polymeric structures as one-dimen-
sional photonic band gap crystals. As Terahertz waves have many useful and interesting applications including imaging, ranging, sensing, spectroscopy, and device characterization.

The terahertz region of the electromagnetic spectrum lies between the microwave and infrared, from a few hundred gigahertz to the low tens of terahertz.

Research in and application of Terahertz radiation is relatively undeveloped, largely due to the lack of bright sources and sensitive detectors of Terahertz. Additionally, modern technology is centered around semiconductor materials, and conventional semiconductor devices are currently limited to operation in the microwave and near-infrared regions, which lie on either side of the millimeter-wave and Terahertz frequency range. Thus there is a Terahertz gap where few devices are available.

Terahertz waves have many useful and interesting applications including imaging, ranging, sensing, spectroscopy, and device characterization.

Both active and passive devices for Terahertz generation, detection, and control are not well developed. Polymeric materials are an excellent candidate for some of these applications.

• Low cost
• Inexpensive and easy to process
• Technology that allows forced assembly of layer structures has been developed

Inexpensive and easy to process

One-Dimensional Photonic Band Gap Crystal

Photic crystals are periodic structures which forbid the propagation of photons of certain energy, or equivalently, electromagnetic radiation of certain wavelength. Analogous to electronic semiconductor materials, a periodic lattice of varying refractive index produces optical band gaps inhibiting photons of particular frequency from transmitting through the material.

One-dimensional photonic band gap crystals are periodic in one dimension and are typically constructed as multilayer films. The allowed wavelengths can be controlled by selecting the thicknesses of the high- and low-index layers to result in constructive or destructive interference of the reflected and transmitted waves. Each layer thickness is chosen to give an optical path length nd equal to \( \lambda / 4 \). The total optical path length reflecting through each layer \( \lambda / 4 \) from the physical layer thickness plus an additional \( \lambda / 2 \) from a phase shift of \( \pi \) on passing from one layer to the next layer. The total path length difference is \( \lambda / 4 \), putting all reflected emerging beams in phase.

If the order of the layers has the high- index material first, the reflectance is enhanced and the resulting structure is commonly known as a dielectric mirror.

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References


Key Points
- The terahertz region of the electromagnetic spectrum lies between the microwave and infrared, from a few hundred gigahertz to the low tens of terahertz.
- Research in and application of Terahertz radiation is relatively undeveloped, largely due to the lack of bright sources and sensitive detectors of Terahertz.
- One-dimensional photonic band gap crystals are periodic in one dimension and are typically constructed as multilayer films.
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