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Liquid crystal based tunable Quasicrystalline photonic structures

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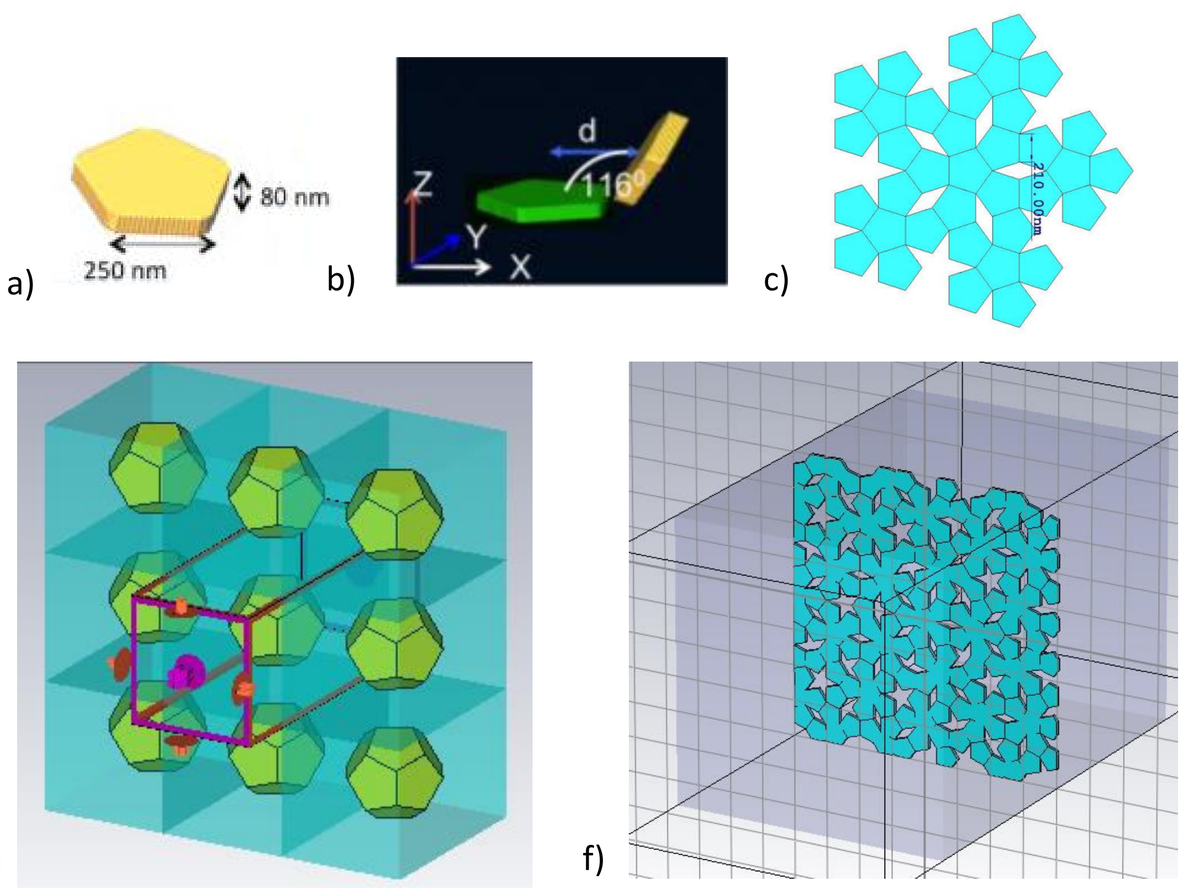
Introduction:

- In the present work we study the resonant characteristics of periodic lattice (Dodecahedron shells) and quasi periodic (Penrose tiling) structures
- We self-organize 3D quasicrystal, specifically dodecahedron from pentagonal platelets bottom-up in nematic liquid crystal. Further, we present the FDTD simulation results of the light-matter interaction of the dodecahedron made with gold platelets across the wave-lengths. Optical properties of periodic lattice of such metallic 3D shells using full-wave electromagnetic simulations are investigated using a commercial software CST and comparison with 3D spherical shell periodic lattice is reported further.
- Secondly, we investigate the effect of quasicrystalline symmetry on the electromagnetic response of Penrose tiling comprising of pentagonal shaped sub-micron dielectric structures made of Te and its compare them to 3D quasicrystal dodecahedron periodic lattice
- Liquid crystals are highly birefringent dielectric materials with low losses. The fast response of the liquid crystals to the external stimuli like temperature, electric field, etc., makes them suitable for designing tunable metamaterials and have potential applications in designing novel optical elements.

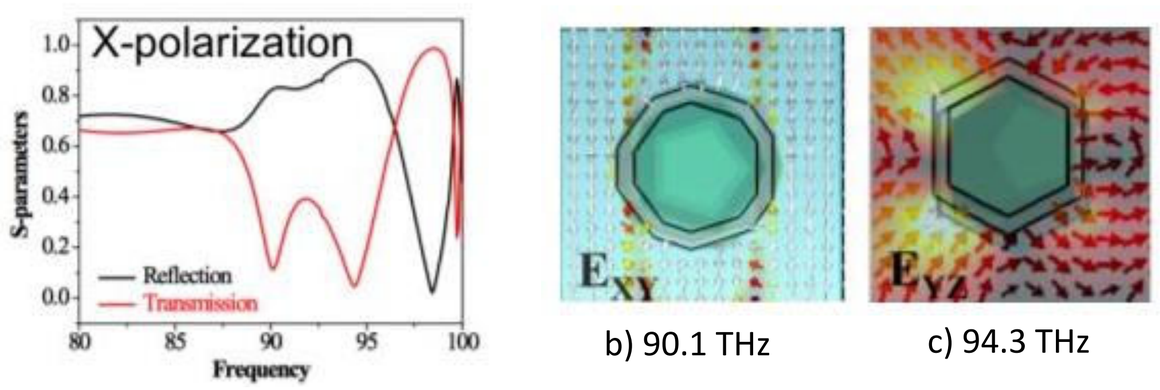
Structure Design:



a) b) c) d) f)

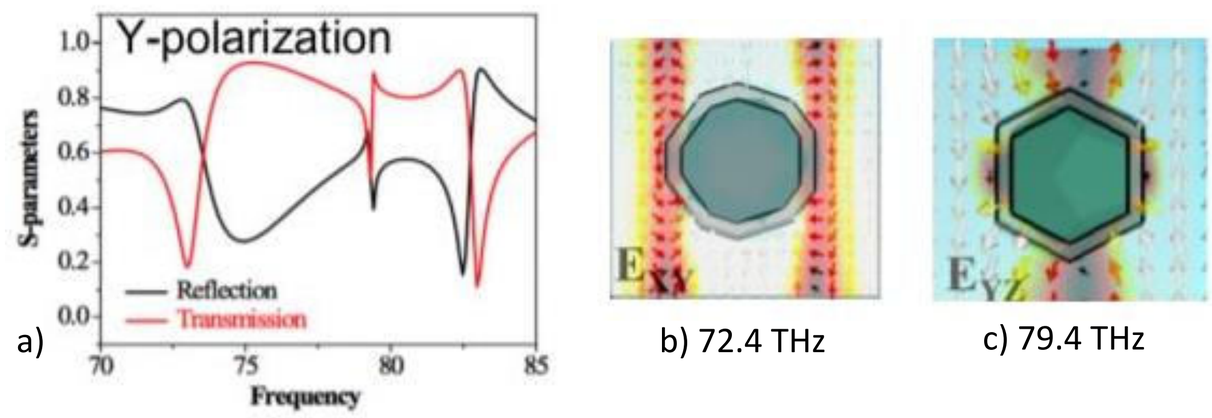
Figure 1: (a) Gold Pentagon dimensions for dodecahedron (b) Di-hedral angle of dodecahedron (c) Penrose tiling with pentagon of side 210 nm (d) Periodic Dodecahedron stuctures with inner radius 1um and outer radius 1.2um (e) Penrose tiling in medium

Simulations:



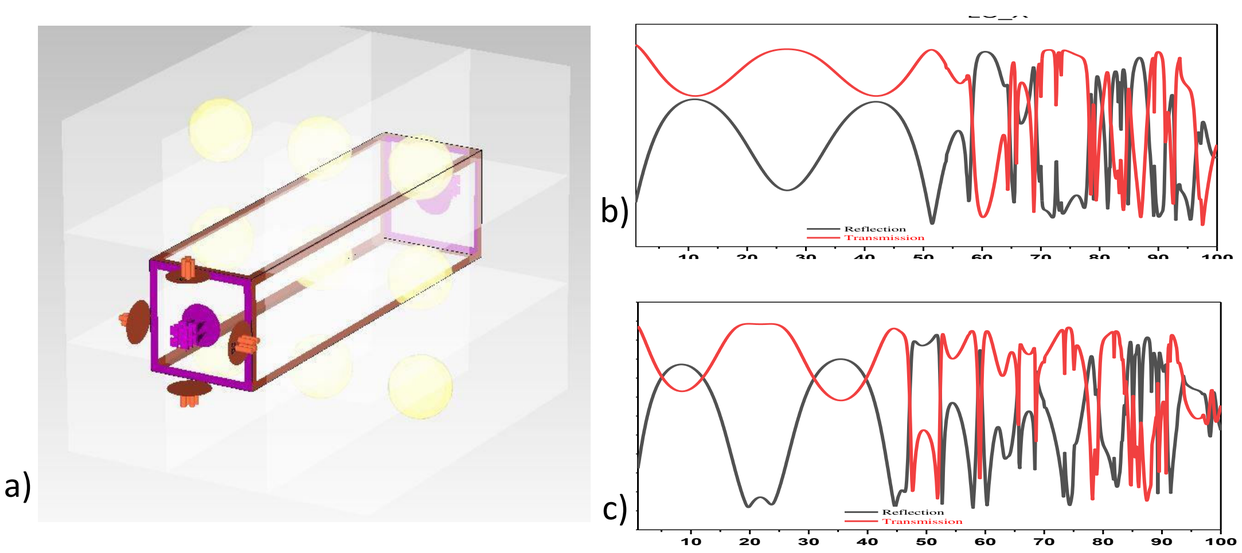
a) b) 90.1 THz c) 94.3 THz

Figure 2: (a) – (c) Scattering parameters for incident X polarized light as a function of incident frequency in THz and corresponding field profiles



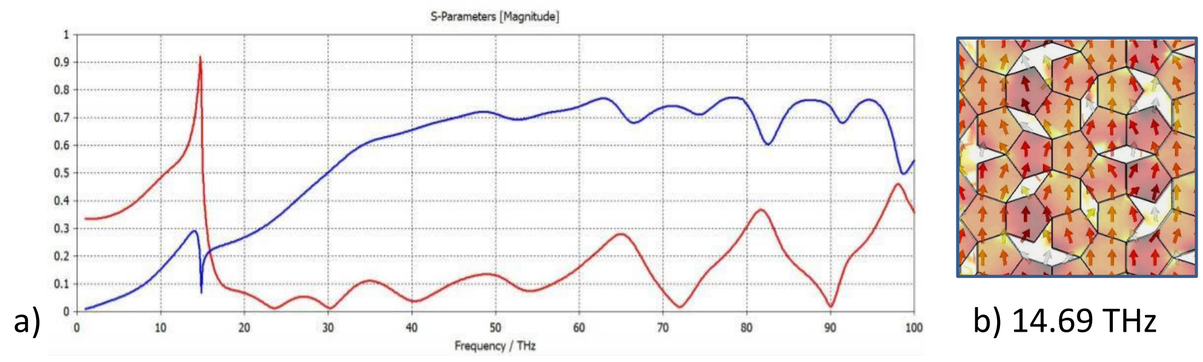
a) b) 72.4 THz c) 79.4 THz

Figure 3: (a) – (c) Scattering parameters for incident Y polarized light as a function of incident frequency in THz and corresponding field profiles



a) b) c)

Figure 4: (a) Periodic structures with Au spherical shells (b) Scattering parameters for incident X polarized light for spherical shell periodic lattice (c) Scattering parameters for incident Y polarized light for spherical shell periodic lattice



a) b) 14.69 THz

Figure 5: (a) – (b) Scattering parameters for incident circular polarized light as a function of incident frequency in THz and corresponding field profiles for penrose tiling

Conclusions:

- The scattering parameter of the periodic dodecahedron shells are found to be same as the scattering parameters of the periodic spherical shells
- The parameters of the 2D penrose tiling are different from its 3D counterparts
- The response has a sharp Q-factor due to the excitation of electric dipole mode. More significantly, it is observed that the metasurface exhibits circular polarization (CP) in certain frequency bands and also can be designed to convert right circular polarization to left and vice versa making them optically active meta surfaces.

Important References:

- Sai Praneeth Madduri, Anja Bregar, Raviteja Reddy Mosali, Pratiksha Sakhare, Miha Ravnik, and Jayasri Dontabhaktunia, “Liquid crystal based tunable 3D Quasicrystalline photonic structures”, *to be published*

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