Smart Design of IR Scene Generation Using Metallic Photonic Crystals

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Infrared scene generators are an important tool for simulating missile plumes and aerodynamically heated targets in testing and validating the imaging and tracking optics. Current systems use square arrays of Joule-heated pixels or micromirrors illuminated with arc lamps in each spectral channel. The limitation is that heated pixels cannot simulate bodies above 1000K before thermal failure. Micromirror systems can time-multiplex, but this requires the lamp to be ~3X hotter than the simulated targets. Here we propose an alternate approach based on photonic crystals (PCs).

In a metallic PC, in particular one with network topology, complete suppression of long wavelength states that lie below the PC-gap cutoff wavelength occurs. The photon states, as a result, are redistributed and amplified at the photonic band-edge. Thus by placing the PC in contact with the heating element and/or deriving it electrically and using it as the actual heat source, this redistribution of the photon states allows us to recycle the energy, otherwise emitted in non-functional bands, and funnel it into the desired bands for scene generation. Thereby boosting the overall emitter device efficiency capped only now by the overall energy emitted from the heating source. To alleviate the observed polarization anisotropy and narrow the angular spread one has to note that while the angular distribution of the emission peak is sensitive to the symmetry of the crystal as viewed from the polar angle θ the polarization sensitivity is tied to the azimuthal angle ϕ.

To reduce the angle spread the requirement is thus translates to requiring crystal structures belonging to higher symmetry groups, and hence brillouin zone approaching sphericity. However since we have to maintain a network topology to allow for energy recycling, for this objective we will thus investigate structures belonging to the face centered cubic family (FCC). On the other hand, the elimination and/or reduction in the polarization dependence of the emission spectrum mandates that the emission surface be azimuthally symmetric, this in turn implies a higher axis of symmetry normal to the emitting surface. For this purpose we will study hexagonal based surfaces that posses a C_6 axis. The combined requirement thus leads planar-diamond like or flat hexagonal crystals stacked in an ABC type of lattice. Single unit cells of such lattices have been already fabricated successfully by Sandia. Theoretical results pertaining to the PC lattice emission optimization and the effects of different topologies will be presented and contrasted to experimental data.