

Metamaterials for Thermal Emission

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Abstract: We discuss the thermal emission properties of two kind of metamaterial structures: a) a metamaterial wire medium slab and b) a subwavelength metallic grating below its first diffraction order.

OCIS codes (160.3918) Metamaterials; (120.6810) Thermal effects; (040.3060) Infrared.

Thermal radiation sources, such as a blackbody or the incandescent tungsten filament of a light bulb, are usually incoherent and omni-directional in nature. Nevertheless, in the last decade many theoretical and experimental works have demonstrated that temporally and/or spatially coherent (i.e. directional) thermal emission is possible. In this work the thermal emission properties of a metamaterial (MM) wire medium slab (Fig.1(a)) [1] and of a subwavelength metallic grating below its first diffraction order (Fig.1(b)) are theoretically analyzed.

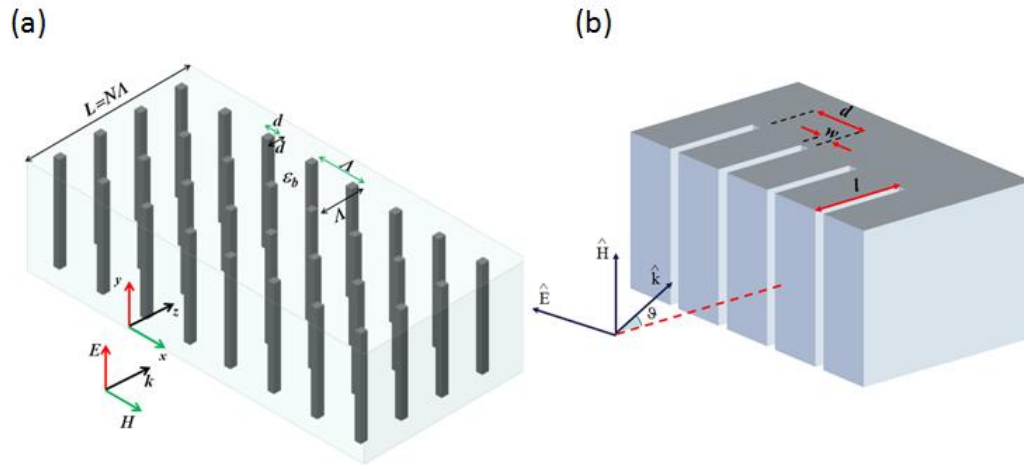


Figure 1: (a) MM wire medium made of metallic columns of square cross-section $d \times d$ arranged in a cubic lattice of period Λ and embedded in a generic host medium with electric permittivity ϵ_b . The MM is finite over the z -direction with a thickness $L = N\Lambda$, where N is the number of rows of nanocolumns. We consider a plane, electromagnetic wave at normal incidence with electric field polarized along the wires. (b) A metallic grating of thickness l , slit aperture w and period d with one side of the grating closed by a back mirror. We consider a TM polarized wave impinging on the metallic grating.

For the MM wire medium embedded in a dielectric host we highlight two different regimes for efficient emission, respectively characterized by broadband emission near the effective plasma frequency of the metamaterial, and by narrow-band resonant emission at the band-edge in the Bragg scattering regime. We discuss how to control the spectral position and relative strength of these two emission mechanisms by varying the geometrical parameters of the proposed metamaterial and its temperature. For the metallic grating, we demonstrate the possibility of realizing temporally coherent, wide-angle, thermal radiation sources based on the metamaterial properties of metallic gratings. In contrast to other approaches, we do not rely on the excitation of surface waves such as phonon-polaritons, plasmon-polaritons, or guided mode resonances along the grating, nor on the absorption resonances of extremely shallow metallic grating. Instead we exploit the effective MM bulk properties of a thick metallic grating below the first diffraction order. We analytically model both physical mechanisms and validate our theoretical predictions with full-wave numerical simulations.

References

[1] G. D'Aguzzano, N. Mattiucci, A. Alù, C. Argyropoulos, J.V. Foreman, M.J. Bloemer, "Thermal emission from a metamaterial wire medium slab", *Opt. Expr.* **20**, 9784 (2012)