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High temperature nanophotonics: Controlling the flow of thermal radiation

V. Rinnerbauer, S. Ndao, Y. X. Yeng, P. Bermel, J. Senkevich, I. Celanovic and M. Soljacic
Massachusetts Institute of Technology, USA

After decades of intense studies focused on cryogenic and room temperature nanophotonics, scientific interest is turning towards high-temperature nanophotonics aimed at solid-state energy conversion– and for a good reason. These latest extensive research efforts are spurred by a renewed interest in thermophotovoltaics (TPV), solar-thermophotovoltaics, solar-thermal, and solar-thermochemical energy conversion systems, to name a few, that benefited from the developments in the field of high-performance narrow bandgap photovoltaic cells—enabling efficient solid-state thermal to electric energy conversion. However, to achieve the impressive efficiencies predicted by theoretical studies, a high degree of control of both spectral and angular emission properties of thermal emitters is needed. We will show how a class of metallic photonic crystals can be designed to efficiently tailor the spectral and angular emission properties, paving the way towards highly efficient thermophotovoltaic systems and enabling other energy conversion schemes based on high-performance high-temperature nanoscale photonic materials.

We have demonstrated—based on the theory, modeling, and experimental results—that two-dimensional (2D) metallic photonic crystals (PhC) hold immense potential for high-performance, high-temperature, spectrally and directionally selective thermal emitters. In particular, we designed, fabricated, and fully characterized high-temperature optical properties, including the thermal emission, of tungsten and tantalum 2D PhCs, both promising for high-temperature (> 1000°C) applications. Our recent investigations of high aspect ratio tantalum 2D PhCs show enhancement of the emittance at wavelengths below cut-off wavelength approaching that of blackbody, steep cut-off and a high level of spectral selectivity. In addition, detailed simulations and analytical modeling show excellent agreement with experimental results.

Biography

Veronika Rinnerbauer has obtained her master from the Technical University of Vienna and her Ph.D from the Johannes Kepler University of Linz, Austria. After 3 years of experience in industry, she is the recipient of an Erwin-Schrödinger Fellowship of the Austrian Science Fund and currently a postdoctoral fellow at the Massachusetts Institute of technology in the group of Marin Soljačić, working on high temperature nanophotonics.

vrinner@mit.edu