229f Quantum Insulators: Photonic Structures with Wide Ir Band Gaps

Hae-Kwon Jeong, Mark A. Shannon, and Richard I. Masel

There is a great deal of demands on small scale power sources due to the increasing miniaturization of MEMS devices and the ever-growing quest for light-weight/long lasting portable electronics. One of the bottle necks the research communities face is, however, the limitation to the available micro power sources. Batteries are hardly considered to be a choice because they suffer from heavy weight and low power density. Micro-combustor can be a solution since they can provide high energy and power density in small scale1,2. To realize micro-combustor technology into real applications, proper thermal management is critical. Here are some issues related to the elevated temperature operation, where heat transfers mostly through radiation: 1) one needs to build multiple radiative shields with high reflectivity and low absorptance (difficult to build such multiple shields in microscale), 2) oxidization environments are hardly avoidable (hard to maintain vacuum in microscale), and 3) metals, good reflectors, can not be used in such oxidation environment (metal oxides are typically poor reflectors). In order to address these issues, it is, therefore, vital to come up with novel microscale insulting systems governed by different physics other than Fourier's law and Stefan-Boltzmann's law of radiation. Photonic materials with complete band gaps in infra-red region (which we call "Quantum Insulators") can provide new ways to build effective insulting systems in microscale3. The photonic band gap (PBG) in IR region can be engineered by varying material and structural properties, so that desired band gaps could be achieved. The structures of multiple length scales can cover wide range of PBG4. In this talk, we will present new fabrication methods to build quantum insulators in cost effective ways. The photonic structure are constructed using 3D photoresist (SU-8 and dry PR) structures as templates. Their optical properties are measured using FT-IR spectrometer. We will also talk about the computation of the photonic band gaps in view of the photonic structure-quantum property relationships to create designer insulating materials.

1. Fernandez-Pello, A. C. Proceedings of the Combustion Institute 29, 883-899 (2002). 2. Masel, R. I. & Shannon, M. A. (US, 2001). 3. Fleming, J. G., Lin, S. Y., El-Kady, I., Biswas, R. & Ho, K. M. All-metallic three-dimensional photonic crystals with a large infrared bandgap. Nature 417, 52-55 (2002). 4. Joannopoulos, J. D., Meade, R. D. & Winn, J. N. Photonic Crystals, Molding the Flow of Light (Princeton University Press, Princeton, 1995).