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Microcavity Discharge Devices and Arrays: A Photonic Platform for Photodetectors, Optical Amplifiers and Displays

J. GARY EDEN, University of Illinois

Microcavity plasma is the term associated with the spatial confinement of a nonequilibrium plasma to a cavity having a characteristic dimension below nominally 500 μm. Recently, fabrication techniques developed largely by the semiconductor and MEMs communities have been adapted to realize a family of microcavity plasma (microplasma) devices with cross-sectional dimensions as small as (10 μm)^2. Fabricated in a wide range of materials platforms, including Si, ceramics, and metal/dielectric multilayer structures, these devices exhibit a number of intriguing properties. These include: 1) the ability to operate on a continuous basis at pressures of one atmosphere and above, 2) specific power loadings of at least tens of kW-cm^{-3}, and 3) microcavity volumes of nanoliters or picoliters. This talk will summarize the properties of microcavity plasmas with characteristic dimensions in the 10-150 μm range, and operating at gas pressures up to $\sim$1200 Torr. Emphasis will be placed on the scientific opportunities afforded by: 1) the access provided by microcavity plasmas to a new region of parameter space, and 2) the ability to now interface a low temperature plasma with an electronic or optical material. Several examples of photonic structures and their applications will be presented, including the recent development of arrays of 250,000 (500 $\times$ 500) inverted pyramid microcavity devices fabricated in silicon. Having an active area of 25 cm^2, this array has been operated in both the rare gases and Ar/N_2 mixtures, and yields luminous efficacies >5 lumens/W when coupled with a commercial green phosphor (Mn:Zn_2SiO_4). Ceramic microchips offering a microplasma gain length of 1-2 cm have also been developed and gain on the 460.3 nm transition of Xe^+ has been observed. Applications of microplasmas in biomedical diagnostics and optics will also be discussed.