Raman-based Mid-infrared Silicon Photonic

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Raman scattering has been successfully used to demonstrate Lasers [1,2] and amplifiers [3,4] insilicon waveguides. Additionally, simulations been shown that in Si/Ge superlattices, acoustic vibrational modes can be made Raman active, making it possible to engineer the Raman spectrum [5]. The maximum output power of the Raman laser is still limited by the nonlinear losses and the presence of free carriers also increases the on-chip heat dissipation. The two-photon absorption effect which is responsible for creation of free carriers in Silicon is found to reduce significantly when pumped at wavelengths less than half the band gap (~2.2μm) [6]. This implies that Silicon Raman lasers pumped at mid infrared (MIR) wavelengths can operate without the competing nonlinear loss mechanisms. The linear absorption loss data [6] for Silicon also suggests that the low-loss window extends from 1.1μm to 8μm. In addition to this, the absence of suitable semiconductor lasers at MIR wavelengths along with the good thermal conductivity and high damage threshold of Silicon is expected to make it a potentially viable material for realizing MIR wavelength Raman devices.

MIR wavelengths in the range of 2-5μm is an important band for free space communications, bio-chemical detection and certain medical applications. Most gases and biological compounds have fundamental resonances at the MIR and can be detected using these lasers. The strong absorption of water and skin cells at these wavelengths renders theses lasers as attractive tools for dentistry, plastic surgery etc. The implementation of Silicon Raman devices at these wavelengths could potentially miniaturize the devices used in these applications. Moreover, the inherent Stokes tunability with pump wavelength and the prospects of cascaded stokes emission could also help achieve wavelengths not easily reachable using other schemes. This talk proposes a new technology, i.e. Silicon Raman lasers that operate at MIR wavelengths, and discusses its applications. It will be shown that silicon is one of the best MIR Raman crystals, even when compared to the best solid state crystals. In addition, this talk will introduce an entirely new concept: that of energy harvesting in photonic device [7].

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