Phase-Change Mid-Infrared Microcavity Photonics

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Control of plasmonic/dielectric resonance using phase-change materials has been attracting growing attentions in the emerging field of reconfigurable meta-surfaces and meta-devices. In the visible to near-infrared region, however, phase-change materials generally have strong absorption and it causes optical loss and degradation of resonance characteristics. The situation is much better in the mid-infrared, where the imaginary part of refractive index almost vanishes for the amorphous state. In this presentation, we discuss two possible applications of modification of mid-infrared light confinement in microcavities using a GeSbTe thin film.

Coding images or spatial structures into a lower dimensional signal space is the most critical process in terms of time, cost and energy efficiency in intelligent information processing, including machine learning and artificial intelligence. In this study we propose a method to encode a two-dimensional subwavelength pattern (image) into the mid-infrared optical spectrum. A silicon microcavity (Fig. 1(a)) is used to generate light confinement modes with a variety of field distributions and a wide range of resonant peaks. An amorphous phase-change film, which covers the microcavity, memorizes the two-dimensional pattern projected on the surface of microcavity by allowing partial crystallization and thus modifies the optical spectrum due to the change in refractive index of the phase-change film (Fig. 1(b)).

Among various mid-IR spectroscopic techniques, surface enhanced IR absorption is the most promising approach to obtain advantageously high spectral sensitivity. For efficient surface field enhancement in the mid-IR region, surface phonon polariton (SPhP) in polar dielectrics are attracting attentions due to their extremely lower loss than plasmonic metal. Although the advantage of SPhP is characterized by the narrowband response, it requires fine tunability to match the SPhP absorption band with a specific vibrational mode of target chemical species. In this study, for spectral tuning of SPhP resonance, we propose to employ GeSbTe reflection mirrors to confine the SPhP (Fig. 2(a)). Narrow absorption band and the tunability of SPhP supported by SiC are experimentally demonstrated (Fig. 2(b)).

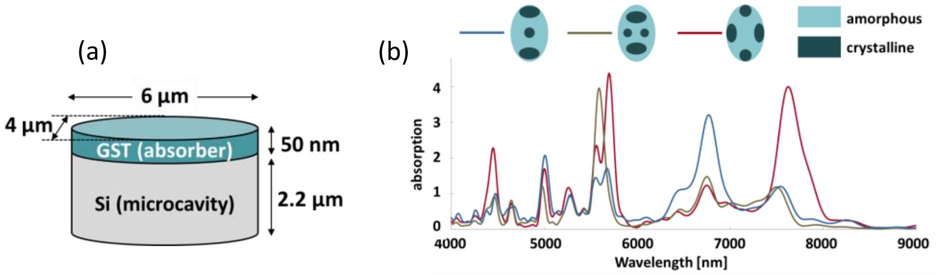

Figure 1 (a) Silicon microcavity covered with a GeSbTe layer (b) Absorption spectra obtained by FDTD simulation for three different crystallization patterns of GeSbTe layer.

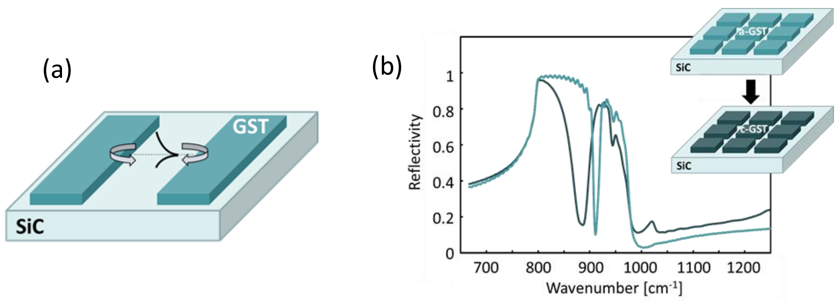

Figure 2 (a) SiC microresonator with GeSbTe reflecting mirrors. (b) Reflection spectra of GeSbTe patch/SiC structure for GeSbTe in amorphous and crystalline phases.