Mid-IR photothermal measurement of substantial heat transport by surface waves of polar amorphous films supported on silicon

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We present measurements of significant thermal diffusivity by surface electromagnetic waves of an ultra-thin polar and amorphous dielectric film deposited on silicon (Si). We used a photothermal-beam-deflection technique with a modulated mid-infrared heating source to excite and launch surface electromagnetic waves onto the surface of an amorphous silicon carbide (a-SiC) film deposited on Si and generate periodic temperature and refractive index gradients above the sample surface. These gradients are capable of periodically deflecting a probe beam, passing very close to the surface, at the modulation frequency of the heating beam. We have fitted the measured probe beam deflection to an analytical model for the mirage effect that takes into account the thermal anisotropy of the measured sample to infer the contribution of the surface electromagnetic waves of the a-SiC film to thermal diffusivity in the plane of the sample under study. We found that reducing the thickness of the a-SiC film promotes the interaction between the surface electromagnetic waves propagating on either side of the a-SiC film, which significantly enhances thermal diffusivity in the plane of the measured sample. We also found that in-plane thermal diffusivity by surface electromagnetic waves on an amorphous silicon carbide film a few nanometers thick is several orders of magnitude greater than thermal diffusivity by phonons in silicon. We believe that the results obtained provide a better understanding of the physics of electromagnetic waves confined to solid surfaces.