Surface Phonon Polariton Coupling to 4H SiC Triangular Gratings Produced by Two-Photon Polymerization

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Surface phonon polaritons (SPhPs) are a promising alternative to plasmon polaritons for localizing mid-IR to terahertz light in the nanoscale with low optical loss and higher quality factor. However, to excite SPhPs modes on the crystal surface, additional in-plane momentum needs to be added with methods such as grating coupling or evanescent fields from prism internal reflections. Previous work on square gratings has been limited by unwanted spatial frequencies and difficulty adding desired spatial frequencies, limiting their functionality [1]. Here, we propose using sinusoidal gratings as a Fourier surface to couple input light to surface modes and design the diffractive properties of the surface accordingly. Two-photon polymerization enables the creation of 2.5D metasurfaces of arbitrary shape on various materials.

In this work, we demonstrate the ability to produce metallic-like triangular one-dimensional gratings using a Photonic Professional GT2 Nanoscribe. We produced 4H SiC triangular gratings that support surface phonon polariton resonances within the Reststrahlen band of SiC between 797 cm^{-1} and 972 cm^{-1}. Gratings were produced by etching a grayscale mask into the SiC substrate, resulting in triangular gratings with periods varying from 1 to 6.2 μm and heights varying from 0.3 to 2 μm. The Q factors of the resonances within the Reststrahlen band were in the range of 50-110, as expected from a low-loss phonon polar dielectric. To understand the origin of these surface phonon polariton resonances, we performed finite element calculations using COMSOL showing good agreement between theory and experiment.

[1] Caglayan, Humeyra, et al. "Near-infrared metatronic nanocircuits by design." *Physical review letters* 111.7 (2013): 073904.

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