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Tuning Short-Wave InfraRed absorption in GeSn nanopillar arrays

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Engineering light absorption in GeSn structures is crucial to enhance their basic device performance for a variety of applications such as MIR photodetectors and solar cells. Surface texturing to reduce the reflectivity is a key strategy to tune the optical properties. Since Group IV semiconductors typically have large refractive indices compared to air (between 3.4 and 4.2), planar opto-electronic devices are plagued by this refractive index mismatch. A promising method to circumvent this limitation is the use of semiconductor nanowires arranged in arrays covering an area of macroscopic dimensions. Top-down etched GeSn nanopillar arrays were microfabricated with varying geometrical configuration. Visible and near IR spectroscopic ellipsometry measurement was undertaken in the spectral range from 900 nm to 2500 nm to evaluate the complex optical constant (n and k) for a 10% GeSn material to allow for an accurate finite-difference time-domain (FDTD) theoretical investigation of the absorptance of GeSn-based nanopillar arrays with different key geometrical parameters (diameter, pillar height, tapering, incidence angle). Additionally, spectral transmittance, reflectance and absorptance of the nanopillar arrays were measured using an integrating sphere in the SWIR spectral range. The presence of absorption enhancement modes in the vertical cavity are explained by the interplay between the HE1m waveguide modes which lead to optimized absorption due to light propagation along the nanopillars axis and the leaky resonance mode. The ability to manipulate light-matter interactions at the nanometer scale with GeSn is opening up new opportunities for spectral tunability in the SWIR range.

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