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Low-loss, localized surface phonon polariton modes in silicon carbide nanopillars: Beyond plasmonics

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While plasmonic nanopillars have attracted attention for their ability to achieve extreme sub-wavelength photon confinement, large concentrations of optical energy, and enhancements to various optical processes, one primary outstanding limitation remains; deleterious lossiness. Therefore, it is highly desirable to identify new materials capable of supporting such subwavelength electromagnetic modes without the disadvantages that arise from losses. Here we report on nanopillars fabricated from semi-insulating silicon carbide as one potential system for meeting these goals in the mid-wave IR, in particular in the DoD and commercially important 8-12 um atmospheric window. Confined electromagnetic modes can be supported by optical phonons in polar semiconductors, where the charge separation between the atoms plays the role as the 'carrier' in the plasma. These “bound-charge” surface phonon polaritons are the electromagnetic equivalent of the free-electron plasmons. While electronic plasmas are damped by scattering on a time scale of tens to a hundreds fs, optical phonon modes decay via much weaker anharmonic phonon-phonon interactions on a time scale of a ps. For nanoscale surface modes, this improves the attainable Q factors by an order of magnitude (from several tens to several hundreds). For our initial nanopillar arrays, we find Q-factors upwards of 40, with calculations showing that values up to 300 are possible. With the highest reported Q-factors from silver nanoparticles featuring sub-wavelength modes falling at just about 40 in the visible, and values in the single digits for in the mid-IR, phonon polaritonic systems hold great promise as an alternative for molecular sensing and enhanced detectors and emitters in the IR spectral range.

Biography

Joshua Caldwell received his B.A. in Chemistry and minor in history from Virginia Tech in May, 2000 also working as a coop engineer at ITT Night Vision in Roanoke, Va. He undertook his graduate work in Physical Chemistry at the University of Florida, graduating in 2004 after which he began a postdoc at the Naval Research Lab in Washington D.C. He became a full-time staff scientist in 2007. He has published over 70 articles in refereed journals since 2003 and is currently an Assoc. Editor for the Journal of Electronic Materials. Josh is an avid triathlete, runner and cyclist.

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