Symmetry Breaking and Active Fano Resonance Tuning in Dolmen Nanostructures

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Abstract Polar-dielectrics have garnered a lot of attention as an alternative to the metal plasmons to support sub-diffractional confinement of light in the mid-infrared to THz regime due to their very low optical losses (Caldwell JD, Lindsay L, Giannini V, Vurgaftman I, Reinecke TL, Maier SA, Glembocki OJ: Nanophotonics 4(44), 2015). The surface phonon polariton (SPhP) in SiC, a polar dielectric, is formed when the optical phonon vibration in the crystal lattice couple with the incident radiation. Recently coupled phononic SiC nanostructures have received enormous attention both in basic research and applied research (Caldwell JD, Glembocki OJ, Francescato Y, Sharac N, Giannini V, Bezares FJ, Long JP, Owrutsky JC, Vurgaftman I, Tischler JG, Wheeler VD, Bassim ND, Shirey LM, Kasica R, Maier SA: Nano Lett 13:3690, 2013; Ellis CT, Tischler JG, Glembocki OJ, Bezares FJ, Giles AJ, Kasica R, Shirey LM, Owrutsky JC, Chigrin DN, Caldwell JD: Sci Rep 6(32959), 2016). In this work, we fabricate a metasurface in the form of SiC nanostructured dolmen structures from a 4H-SiC substrate, which enables creation of new optical modes via periodicity induced symmetry breaking that are active in the Reststrahlen band region (window between the transverse and longitudinal optical phonons). The polarisation dependent far field studies reveal that the nanostructures exhibit very strong dipolar and quadrupolar resonances and the interaction between the radiant, broader dipolar modes with the narrow, sub-radiant quadrupolar modes gives rise to a unique asymmetric Fano type of resonance. By controlling the geometry and spacing of the features in the dolmen we notice that the resonances can be highly tunable, resulting in exceptional optical properties highly desirable to enhance the performance of various nanophotonic applications.

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