Optically triggered semiconductor hyperbolic metamaterial for controlled single photon emission

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Quantum photonics opens doors for applications in sensing, data transfer, quantum computing. A key technological hurdle is a system for controlled single photon emission. Hyperbolic metamaterials, composed of metallic building blocks embedded in dielectric media control emission lifetime by modifying the photon density of states. However, limited previous efforts have explored the transient modification of metamaterials to control emission. Antimony-based semiconductor hyperbolic metamaterials (SHMMs) offer a route to modulation of these resonances at the mid-infrared (IR) wavelength range, which would modulate emission. In this work we propose to demonstrate SHMMs such as InAsSb alloys, and InAs/InAsSb stacks embedded with dielectric GaSb media in which a transient carrier concentration will be generated through optical pumping. Modelling of these films show that optical concentration of 10^{19}-10^{20} e-h/cm^3 would generate responses in the IR range. This transient excitation of the SHMM would enable triggered single photon emission as well as optical gating and modulation. Calculations show 2-3 orders of magnitude change in the photon density of states predicting dramatic changes in the emission rate. If successful, this study would establish a new platform for deterministic single photon emission that would be integrable into opto-electronic platforms and dramatically advance optical quantum technologies. This initial study will serve as an ideal test bed for next-generation plasmonic architectures, where optically engineered metals can be integrated with a loss-less dielectrics to explore the ultimate limits of plasmonic devices.

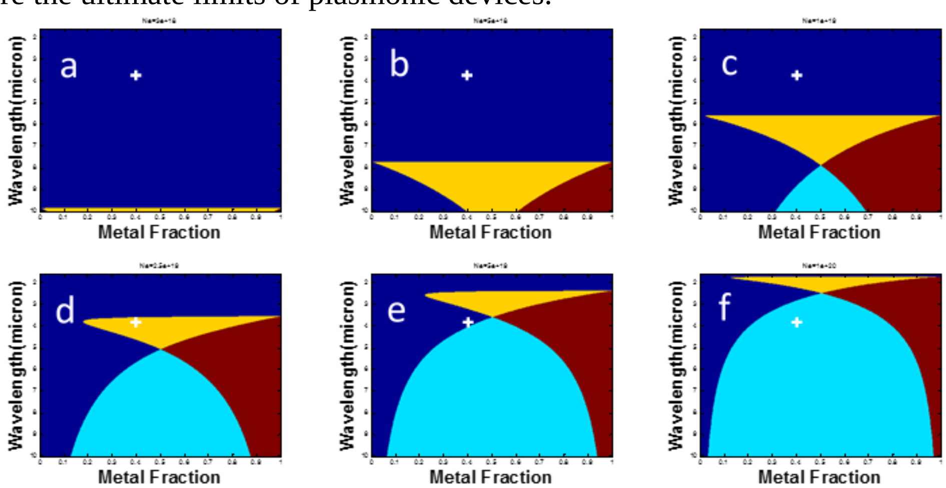

Figure 1 Hyperbolic phase diagrams of InAsSb/GaSb for different e-h concentrations (a) $3x10^{18}$ e-h/cm^3, (b) $5x10^{18}$ e-h/cm^3, (c) $1x10^{19}$ e-h/cm^3, (d) $2.5x10^{19}$ e-h/cm^3, (e) $5x10^{19}$ e-h/cm^3, (f) $1x10^{20}$ e-h/cm^3,The plus sign(+) in the figures corresponds to a fixed wavelength of light for a particular metal fraction

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