Tuning the plasmonic response of heavily-doped semiconductors in epsilon-near-zero regime

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Epsilon-near-zero (ENZ) materials display vanishing permittivity at precise frequencies, e.g., plasma frequency ω_p. They exhibit several peculiar properties such as a unique field enhancement or ultrafast nonlinear efficiencies, and will be useful in the field of integrated Photonics. Heavily doped semiconductors have a tunable ENZ regime over the infrared spectral range by adjusting their doping level and thus their plasma frequency ω_p.

In this work, we investigate the correlation between the localized surface plasmon-polariton resonance and the nano-antenna size within a metal-insulator-metal structure composed of heavily-doped semiconductor InAsSb:Si (Fig. 1 a)). In this study, while the metals have a high plasma frequency ω_{p1}, the insulator is also doped InAsSb:Si at lower plasma frequency ω_{p2}. In doing so, we uncover the origin of the resonance pinning, which has been previously mentioned in the literature, as the spacer permittivity approaches zero [1]. Plus, we demonstrate that doping is an excellent additional degree of freedom to engineer the optical response of plasmonic structures, especially in the ENZ regime where the response becomes nearly geometry-independent, and is rather dispersive dependent (Fig. 1 b)).

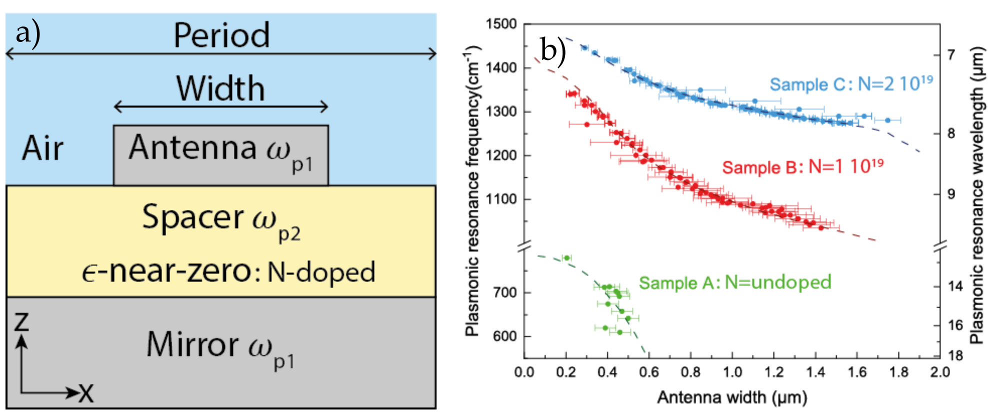

Fig. 1) a) Diagram of the samples. b) Plasmonic resonance as a function of the antennas width (dashed: simulations, points: experimental). We observe the influence of the spacer layer doping level on the geometry-independent behavior, notably Sample C.

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