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Near-field characterization of deep sub-wavelength confinement in InP cavities

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Abstract: Enhancing light-matter interaction has important applications in integrated photonics and quantum technology. Since light-matter interaction strength scales inversely with the mode volume, spatial confinement of light is of significant interest. Silicon dielectric nanocavities have been demonstrated to exhibit sub-wavelength confinement of light without being limited by absorption losses [1]. For integration with active materials, a direct bandgap semiconductor like indium phosphite is favorable.

We report sub-wavelength mode-confinement in an indium phosphide nanocavity [2]. The devices are designed exploiting topology optimization [3] and fabricated with electron-beam lithography and inductively coupled plasma etching. The experimental demonstration of sub-wavelength confinement is carried out by scattering-type scanning near-field optical microscopy with a pseudo-heterodyne detection scheme. Demodulation at higher harmonic orders of the tip tapping frequency enables retrieval of the scattered electric field with a nanoscale spatial resolution. Importantly, we show that the electric field is strongly confined with a mode volume of $0.26(\lambda/2n)^3$.

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