Importantly, the multi-band capabilities of our design opens the possibility to further increase the spatial resolution using nonlinear effects, since the central bow-tie gap is the only spot with high enhancement at multiple wavelengths. A sensing scheme relying on the simultaneous near-field enhancement of several wavelengths in a single nanoscale volume could be implemented using our antenna. More generally, plasmonic antennas capable of focusing light into a single sub-wavelength spot at multiple frequencies, potentially spanning more than one octave as shown here, can be used for a range of novel functions, including the resonant enhancement of both pumping and emission efficiency of nanoscale emitters, background-free sensing of optically trapped nanoparticles, broadband near-field imaging, Raman and fluorescence sensing of multiple molecular targets with nanoscale spatial resolution [11].

5. Conclusion

We have proposed and demonstrated a new antenna structure that provides high electric field enhancement at multiple wavelengths in a single nanoscale focal point. The structure uses the coupling between the LSP resonance of a central bow-tie antenna and the photonic-plasmonic modes of an array of resonant nanoparticles. A simplified design providing a high field enhancement at one selected wavelength was used to study this coupling, through FDTD simulations and far-field transmission experiments. Calculations and experiments confirmed the existence of Fano-like interference phenomena between the two excitation paths of the bow-tie, through direct illumination and through illumination by the scattered field of the surrounding nanoparticle arrays. The near-field of the proposed structures has been imaged using an s-SNOM setup, and the experimental data confirmed the possibility of simultaneous excitation of both the arrays photonic resonances and the central bow-tie nanoantenna. The work presented here gives insight into the interactions between local and collective plasmonic or photonic modes of complex antenna structures and paves the road to the development of broadband nanoantennas with high-spatial resolution that can be utilized as near-field probes for a variety of applications in nanoimaging, spectroscopy and biosensing.

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