Mid-infrared plasmonic nanoantennas fabricated by diffuse photonic nanojet lithography

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Abstract

Plasmonic nanoantennas working in mid-infrared (mid-IR) region have recently received great attention in the field of vibrational spectroscopy due to their ability of enhancing the vibrational mode signal from a small amount of molecules [1,2]. A resonant coupling between the localized surface plasmon and the vibrational mode of molecular bonds is responsible for the signal enhancement. The maximum enhancement occurs when the plasmonic resonance peak coincides with the frequency of molecular vibrations. Therefore, it is of practical significance to develop a simple, cost-effective, and large scale process for versatile fabrication of tailored nanoantennas for a specific vibrational mode.

In this study, we present a novel diffuse photonic nanojet lithography to fabricate rod-type plasmonic nanoantennas whose resonance peaks are located in the mid-IR spectral region. We successfully demonstrated a wide tunability of resonance wavelength in the range of 3-14 μm, simply by controlling the divergence angle of engineered diffuser and the diameter of polystyrene beads. Finite-difference time-domain (FDTD) simulation was also performed to explain the underlined mechanism and shows a remarkable coincidence with the experimental results.

Polarization dependent excitation of longitudinal modes along the long axis of nanoantennas was confirmed and their spectral response to the change in local environment was analyzed with an infrared transparent liquid. Various substrates such as CaF_2, sapphire, and Si were employed to test their effect on plasmonic properties of resonance wavelength and strength. It is observed that the higher index substrates are quite beneficial for tuning resonance wavelength but might deteriorate the sensitivity due to the local field more strongly confined at the interface of nanoantenna with the substrate rather than with the environment.

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References

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Figures