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Shifted nanorods to increase the density of plasmonic hot-spots for nonlinear optics enhancement

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The confinement of the light at the nano-scale and the intense fields due to plasmonics, allow us to enormously increase the local density of states of molecule and nano-objects close to the hot-spots. This can be exploited to enhance nonlinear optical processes, such as surface enhanced Raman scattering (SERS), second harmonic generation (SHG), sum and difference frequency generation (SFG and DFG). Nonlinear optical processes can be enhanced by metasurfaces and nanoantenna arrays with nano-gaps. Plasmonic structures can concentrate the light to sub-wavelength volumes, resulting in hot-spots with very strong fields. A nano-gap is the volume between two pieces of metal, in order to observe a strong field enhancement the distance between the two pieces of metal has to be small, $e.g.$, $\sim$ 10 nm. Nano-gaps are realized by dipole, bowtie, cross-dipole nanoantennas, thus exhibiting polarization dependence and low density, $i.e.$, number of hot-spots per unit area, due to the physical dimensions of the structures. We show how to increase the hot-spot density taking advantage of high order resonance modes in shifted plasmonic nanorods. This configuration allows us to get a field enhancement in the gap for every incident polarization. This can be exploited for all those nonlinear processes where two or more frequencies are involved and the hot-spots need to be co-located and/or co-polarized, for several crystal classes.

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