Local electromagnetic flip-flop in plasmonic infrared trimer nanoantenna as observed by molecular probing

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Metallic Nanostructures (MN) offer the possibility of strong spatial confinement, down to the nanometer scale. In this context, easy remote control of electromagnetic hot spot constitutes an important challenge. In particular, rational control of MN geometry and incident beam shaping (including phase and angle of incidence) can produce a large variety of near-field distribution that can be exploited in the future, e.g. for photonic computing.
Recently, It was theoretically demonstrated that that symmetric and antisymetric modes can be excited, on demand by a propagating plane wave in a linear trimer of identical gold nanoparticles[1] . In this paper, we experimentally demonstrate this effect on plasmonic infrared trimer nanoantenna. Two novelties are emphasized. First, we report direct near-field observation of mode balancing and localization of hot spots in trimer plasmonic nanoantenna. Second, we have used for the first time two-photon absorption in azobenzene moieties for plasmonic nano-imaging of infrared nanoantenna, opening the route to near-field investigation of coupled systems based on molecular probing. The studied nanostructure is shown in Fig. 1(a).

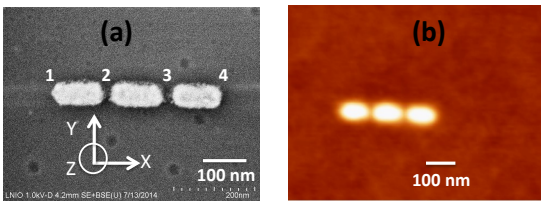

Figure 1. Studied gold nanotrimer

To investigate the optical near-field, we used a specific approach that has been developed over the past decade.[2] Azobenzene molecules that are covalently attached to a polymeric backbone are used as optically driven molecular nanomotors. After exposure to the light, an atomic force microscope (AFM) is used to measure the resulting topography that is related to the near-field intensity pattern to be characterized. Fig. 1(b) shows the plasmonic structure after photopolymer deposition, before any exposure. Figure 2 shows examples of AFM

images taken after exposure (at λ=900 nm) with different incident angles and polarizations. Topographical depletions correspond to electromagnetic hot spots that triggered molecular migration. The results were analyzed and compared with electrodynamics calculation allowing us to discuss field spatial localization.

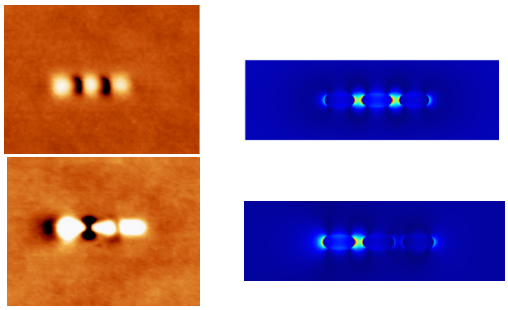

Figure 2. Examples of hot spot localization. Left: AFM images taken after exposure (λ=900 nm). Right: corresponding calculated field maps.

Interestingly, by considering hot spots at both cavities and trimer extremities (named 1, 2, 3, 4 in Fig. 1(a)), we demonstrated the partial activation of a four-digit plasmonic code (cf. example in Fig. 3)
This study opens the avenue to near-field plasmonic circuits and information that are controlled by simple far-field optical commands.

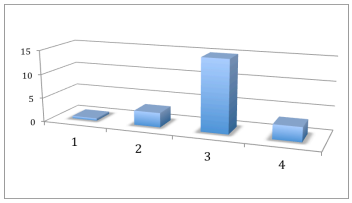

Figure 3. Example of 4-digit plasmonic configuration. 1, 2, 3, 4 stand for the locations pointed out in Fig. 1(a). The heights correspond to depletions in nm observed at each location.

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