Extended Abstracts of the 2012 International Conference on Solid State Devices and Materials, Kyoto, 2012, pp550-551

Plasmonic EM absorbers and photothermal effects

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1. Introductions

Light absorption usually generates heat, which gives rise to many interesting phenomena and important applications. With the help of plasmonic resonances in metallic nanostructures (e.g. array of nanoparticles), light absorption can be significantly enhanced at visible and near-infrared region. Such photothermal effects in plasmonic nanostructures have great potentials in applications for photothermal cancer therapy, optical storage, photo-thermo-voltaics, etc. Most of previous work focused on photothermal effects at visible or near infrared (wavelength <1 μm), while the research on longer wavelength is limited.

Here in this talk, we will present our recent work on plasmonic electromagnetic absorbers at near infrared wavelengths, and the related photothermal effects,

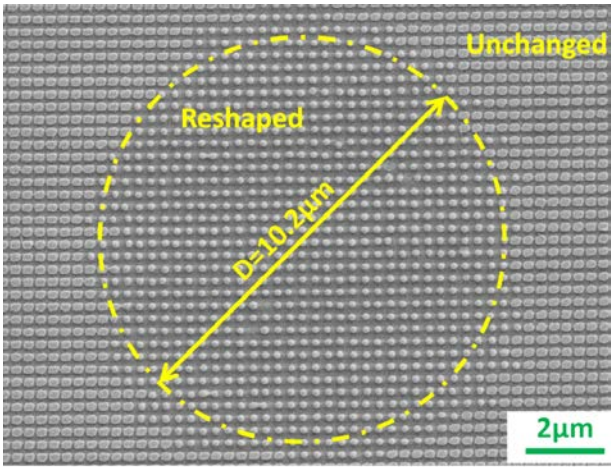

Fig. 1 A plasmonic EM absorber with the central area melted. Note that a clear boundary exists between the melted and the unmelted area.

2. Results

Recently, we have demonstrated plasmonic metamaterial absorbers at optical communication wavelength [1-3], polarization dependent or independent. We have even observed close-to-instantaneous fusion and re-shaping of the nanoparticles with a nanosecond pulse train in such metamaterial absorbers, due to extremely strong photothermal effects enhanced by the plasmonic resonances [4] (See Figs. 1 and 2). The generated heat profile has a subwavelength resolution, and the resonance wavelength can be in principle tailored to arbitrary wavelength region by choosing an appropriate geometry for the resonator structure. We have even developed a heat transfer model to investigate the temporal variation and spatial distribution of temperature in such plasmonic gold nanostructures [5]. The model shows that the temperature of the gold nanoparticles can be raised from room temperature to >600 K in just a few nanoseconds with a low light luminance, owing to enhanced light absorption through strong plasmonic resonance. Our heat transfer model of plasmonic nanostructure can serve as an excellent numerical guideline for designing nanophotonic devices with functioning photothermal properties.

Based on the above photothermal effects, we also propose a novel design of tunable silicon-on-insulator waveguide integrated with a plasmonic nanoheater. Excited with 980nm polarized pump light, the metallic nanoheater is able to efficiently convert the optical power into localized thermal power and drastically raise the surrounding temperature. With pump intensity of 1 mW/μm^2, temperature of silicon waveguide can be raised by 245 K, corresponding to an increase of refractive index of silicon core by 0.049. Theoretically, a compact size Mach-Zehnder interferometer composed of our tunable SOI waveguide can achieve sub-micronsecond response time.

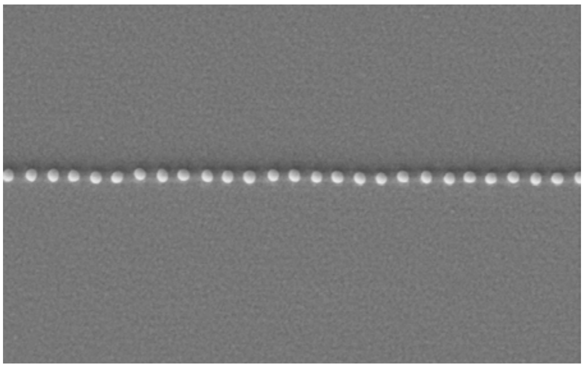

Fig. 2 A line array of gold nanoparticles fabricated based on the photothermal effect.

Other applications of photothermal effects, in particular, for infrared imaging, will also be presented.

Acknowledgements

We would like to thank the support from Zhejiang University, China, the Swedish Foundation for Strategic Research (SSF) and the Swedish Research Council (VR) through the ADOPT center.

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