Fabrication and Characterization of Metal-Dielectric-Metal (MDM) Nanoantennas

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We recently proposed a new design of optical nanoantennas which are composed of two metallic parts stacked vertically with a dielectric spacer. The dielectric nanogaps in such nanoantennas form plasmonic nanocavities. An example of parallel cuboids MDM nanoantenna is schematically shown in Fig. 1a. Our numerical calculations can show that local field and far-field spectra show distinctive cavity resonances which produce sharp peaks in local field spectra (Fig. 1b as an example) and leave their fingerprints as multiple dips in the far field scattering spectra. Numerical results have also shown that the local field enhancements inside the cavity can be tuned by varying the size of the dielectric spacer and that a gap of 5nm or less promises an extraordinary electromagnetic field enhancement of the order of 10^2. The uniqueness of this new design lies in the ability to fabricate them with high accuracy in controlling the plasmonic gap thickness.

In this paper, we will present our recent efforts in fabricating this type of nanoantennas and in characterizing their optical properties. Metal, dielectric and metal layers are sequentially deposited on fused quartz substrates, and parallel cuboids nanoantennas are carved by using focused ion beams (FIB). Exemplary SEM pictures in Fig. 2 show $Ag/Al_2O_3/Ag$ nanoantennas with thickness at 70nm, 3nm, and 70nm milled with 50 keV Ga+ ion and 30 pA beam current (Fig. 2a-b).

Measured scattering and transmission spectra of these nanoantennas will be presented and compared with numerical calculation results, and potential applications of such nanoantennas in surface-enhanced Raman spectroscopy and optoelectronics will be discussed in the conference.

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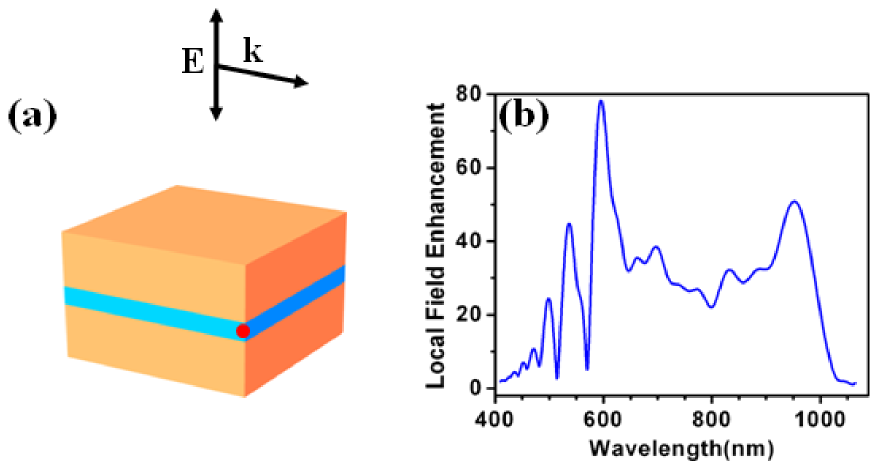

Fig. 1. (a) Schematic representation of MDM ($Ag/Al_2O_3/Ag$) nanoantenna. The arrows represent the direction **k** of the incident light and the direction **E** of the incident electric field; (b) calculated local field enhancement at the exit of the gap as pointed by the red dot in (a). For this particular nanoantenna, the size of the Ag cuboids is set as 60nm×60nm×80nm and Al_2O_3 gap thickness is 1nm.

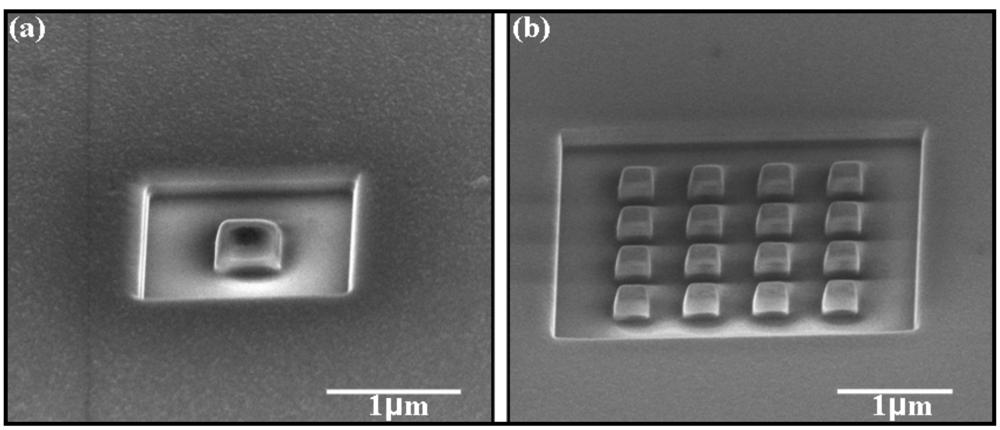

Fig. 2. SEM images of a single 500nm×500nm (a) and a square array of 300nm×300nm cuboids MDM nanoantennas (b) carved in the $Ag/Al_2O_3/Ag$ multilayer on a fused quartz substrate using an FIB system.