Polarization properties of second harmonic signal from monolithic AlGaAs nanoantennas

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Metal-less nanophotonics has recently raised an increasing interest because the optical response of high-permittivity dielectric nanoparticles exhibits negligible dissipative losses and strong magnetic multipole resonances [1–3] in the visible and near-IR. Here we propose all-dielectric $Al_{0.18}Ga_{0.82}As$-on-AlOx nanodiskrs, on which we measure second harmonic generation (SHG) with conversion efficiency up to 10^{-5} for a 1.6 GW/cm^2 pump in the optical telecom wavelength range [4]. Our samples were fabricated from a [100] non-intentionally doped GaAs wafer, with a 400nm layer of $Al_{0.18}Ga_{0.82}As$ on top of an aluminum-rich substrate. We first patterned circles with a scanning electron microscope (SEM) lithography system, followed by ICP-RIE dry etching. Finally the sample was selectively oxidized at 390°C for 30 min. The result is an array of nanoantennas on an aluminum-oxide (AlOx) substrate, as shown in Fig. 1(a).

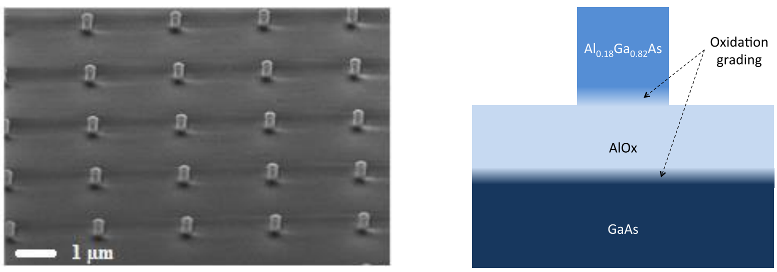

Fig. 1. Monolithic AlGaAs-on-AlOx nanoantennas: a) scanning-electron-microscope picture of a part of the array; b) schematics of a single nanoantenna.

The linear and nonlinear optical response of such nanoantennas are modeled by using frequency-domain finite element simulations in COMSOL [5]. We numerically predict a SH conversion efficiency higher than 10^{-5} for a pump wavelength between 1500 nm and 1700 nm.

To experimentally investigate the nonlinear properties of the fabricated nanopillars, we excited them with an ultrafast Erbium-doped fiber laser centered at 1554 nm (150 fs pulses, 80 MHz repetition rate). SHG signal was collected from an array of nanocylinders with radius varying from 175 to 225 nm, using single-photon avalanche photodiodes. The dependence of the detected SHG on the radius of the nanocylinders is in excellent agreement with the numerical simulations (see Fig. 2a). The polarization of the emitted SHG, reported in Fig. 2b as a function of the nanodisks radius, is also in very good agreement with numerical simulation (see Fig. 2c), demonstrating the strong dependence of the SHG polarization from the nanocavity modes involved for specific nanostructures dimensions [6].

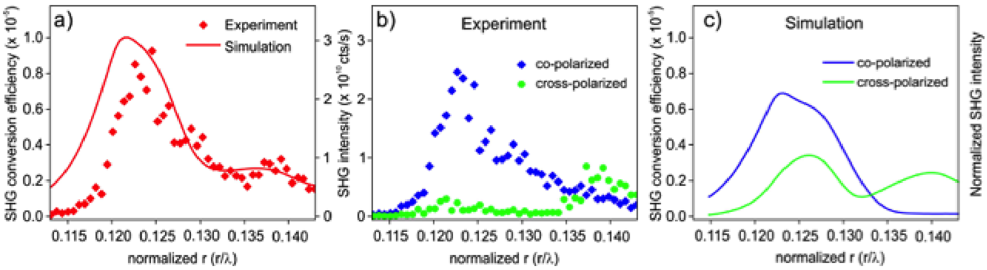

Fig. 2. a) Unpolarized second harmonic emission; b) Experimental polarized emission; c) Simulated polarized conversion efficiency.

Our results allow gaining further insight in the mechanisms underlying the polarized nonlinear emission in these systems, showing the potential of AlGaAs-on-insulator all-dielectric platforms in the nonlinear manipulation of light properties at the nanoscale.

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