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High-contrast monolithic photonic nanostructures in the AlGaAs-on-insulator platform

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Aluminium gallium arsenide (AlGaAs) is a promising material for monolithic photonics. Besides having a high optical Kerr coefficient, this III-V semiconductor alloy has a high χ^((2)); it is a mature laser material; and its direct band-gap can be varied with the Al molar fraction, making it not only linearly transparent from 0.7 μm to 16 μm, but also two-photon-absorption free at 1.55 μm. Several types of AlGaAs high-contrast nonlinear integrated photonic structures have been demonstrated in the last years, spanning from nanowires [1,2] to high-Q resonators [3,4] and multi-pole nanoantennas [5]. To confine photons at sub-wavelength scales, such devices rely on a high-refractive-index core clad by a far lower index in two or three dimensions, and therefore they typically consist of semiconductor nanostructures that either lie on an oxide substrate or are suspended in air. Here we focus on the former case, which seems more promising because of its superior heat-sink behaviour and mechanical stability. Our devices, from the nano- to the micro-scale, share the same fabrication protocol: they are grown by molecular-beam-epitaxy on {100} non-intentionally doped GaAs wafer, with a few hundred nanometres layer of $Al_{0.18}Ga_{0.82}As$ on top of an aluminium-rich substrate, to be oxidized at a later stage (see Figure 1). In order to improve the eventual adhesion between AlOx and the adjacent crystalline layers, such substrate consists of AlAs layer of about 1μm of thickness sandwiched between proper matching layers. A number of nonlinear optics results have been allowed by this class of devices, ranging from second harmonic generation to down-conversion in optical nanoantennas, and from radiation pattern engineering with subwavelengths photonic molecules to frequency conversion in waveguides and resonators. We will provide an overview of this new and exciting research field, along with a few perspectives.

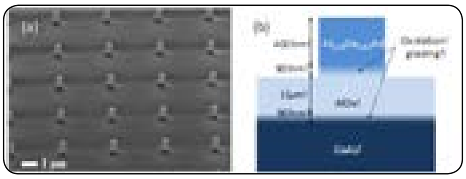

Figure 1: Monolithic AlGaAs-on-AlOx nanoantennas: (a) scanning-electron-microscope picture of a part of the array; (b) schematics of a single nanoantenna

Recent Publications:

1. Scaccabarozzi L et al. (2009) Enhanced second-harmonic generation in AlGaAs/AlxOy tightly confining waveguides and resonant cavities. Opt. Lett. 31: 3626-3629.
2. Morais N et al. (2017) Directionally induced quasi-phase matching in homogeneous AlGaAs waveguides. Opt. Lett. (accepted)
3. Mariani S et al. (2014) Second-harmonic generation in AlGaAs microdisks in the telecom range. Opt. Lett. 39: 3062-3065.
4. Pu M et al. (2016) Efficient frequency comb generation in AlGaAs-on-insulator. Optica 3: 823-826.
5. Gili V F et al. (2016) Monolithic AlGaAs second-harmonic nanoantennas. Opt. Express 24: 15965-15971.

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