Highly nonlinear AlGaAs waveguides for broadband signal generation

C. Lacava[1,2]**_, M.J. Strain_**[3]**_, V. Pusino_**[4]**_, R. Marchetti_**[1]**_, P. Minzioni_**[1]**_, M. Sorel_**[4]**_, I.Cristiani_**[1]

1. *Dipartimento di Ingegneria Industriale e dell'Informazione, Università di Pavia, Via Ferrata 5A, 27100 Pavia, Italy*
2. *Optoelectronic Research Centre, University of Southampton, SO17 1BJ Southampton, United Kingdom*
3. *Institute of Photonics, Department of Physics, University of Strathclyde, Glasgow, G4 0NW, UK*
4. *School of Engineering, University of Glasgow, Glasgow, G12 8LT, UK*

In the last decade silicon on insulator – based waveguides have progressively attracted the attention of the nonlinear-optics research community. Due to the strong refractive index contrast of such waveguides and thanks to the very high nonlinear refractive index of silicon, strong nonlinear effects can be achieved in SOI structures, even at moderate pump power level (e.g. P < 1 mW) [1]. However, silicon also exhibits a very strong nonlinear absorption coefficient that severely limits the waveguide performance at power level above 1 mW. Very recently nonlinear AlGaAs waveguides were demonstrated, showing both efficient continuous wave and pulsed nonlinearities [2] with no two-photon absorption (TPA) effect, even at high power level.

Here we present the nonlinear characterization of low loss – nanosized- AlGaAs waveguides, by means of both continuous wave (CW) and pulsed input signals. The substrate material is a GaAs, with an epistructure consisting of a series of GaAs/AlGaAs layers grown by molecular beam epitaxy. Starting from the substrate, the layers are composed as follows: a lower-cladding layer of $Al_{0.75}Ga_{0.25}As$, a core layer of $Al_{0.25}Ga_{0.75}As$, an upper cladding of $Al_{0.75}Ga_{0.25}As$ and finally a cap layer of GaAs. Fig. 1(a) shows the final structure, including cross-section size details.

Initially the CW behaviour of a set of waveguides with width as a parameter was characterized. In particular, by means of a cutback loss measurement set-up, waveguide losses were measured from 4 dB/cm (for a waveguide width w = 1.2 μm) to 6.5 dB/cm (for, w = 0.6 μm). Such loss values allow using mm-length waveguides to generate efficient nonlinear interactions, and high power level operation is also permitted, due to the absence of TPA [2]. In order to assess the optical nonlinearities of the AlGaAs structures CW - Four Wave Mixing (CW-FWM) experiments were performed, obtaining a maximum nonlinear coefficient of 521 $W^{-1}m^{-1}$ for the 600 nm width waveguide. This value confirms the excellent nonlinear behaviour of such waveguides.

As a final characterization supercontinuum generation was achieved, in the telecom-bandwidth window. The optical signal source was a 120 fs pulsed laser (λ = 1560 nm, at a repetition rate of 82.5 MHz), whose beam was coupled to the waveguide, and then from the waveguide to an optical spectrum analyser, by using two 40 × microscope objectives. The optical spectra measured at the output of the 700 nm-wide waveguide for increasing values of the input-beam power, are reported in Fig. 1 right panel. It can be seen that when the average pump power level is -6 dBm the optical radiation measured at the output covers a range of more than 400 nm.

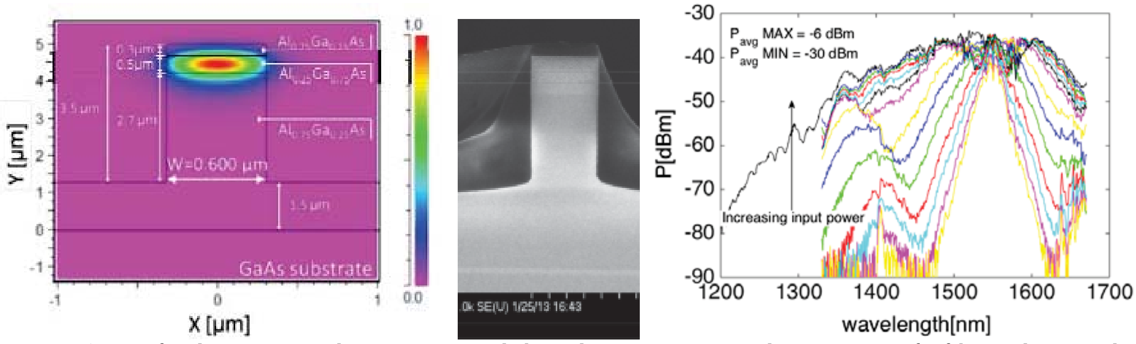

Fig. 1 Left: AlGaAs waveguide cross-section and physical composition; Central: SEM picture of a fabricated waveguide; Right: Nonlinear broadband spectrum generation results for a waveguide with w = 700 nm.

Results clearly show that AlGaAs waveguides can be extensively used to generate broadband spectra in the telecom band by means of a mm-length scale optical waveguides. Continuous wave nonlinear behavior was also characterized by means of CW-FWM experiments. The nonlinear waveguide parameter γ = (521 + i 0) $W^{-1}m^{-1}$, confirms that AlGaAs waveguides can be considered as a promising alternative approach to silicon structures in the field of nonlinear integrated optical components.

References:

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