Linear and nonlinear characterization of vertical orientation-patterned gallium phosphide waveguides for second harmonic generation

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Non-linear photonics is now ubiquitous in many application fields such as telecommunications and quantum technologies. In the framework of octave-spanning spectral conversion, where second-order processes are most relevant, the ability to pattern periodically the nonlinear response of waveguides, achieving the so-called quasi-phase matching (QPM) condition, has led to the demonstration of the highest second harmonic generation (SHG) efficiencies in integrated structures [1-2], at the cost of elaborate fabrication process or limited poling capabilities. The main alternative to QPM in nonlinear photonic waveguides consists in modal phase matching which generally suffers from a small mode overlap, strongly impacting the SHG efficiency. Recently, novel designs of nonlinear waveguides were proposed, based on the vertical control of the material susceptibility rather than its periodic modulation along the propagation length, unlocking modal phase matching configurations with large mode overlap [3-4].

In this work, we developed vertical orientation-patterned (VOP-) GaP nanowaveguides for SHG, allowing us to investigate the conversion of a TE00 pump mode into a TM10 SH mode. In the absence of crystal polarity engineering, this non-linear process has a negligible efficiency due to the odd vertical profile of the SH mode. Reversing the crystal orientation of the material between the lower and upper parts of the waveguide allows the nonlinear polarization profile to match with the TM10 symmetry, resulting in a mode overlap close to the optimal value. To fabricate such a device, two GaP thin films were grown by MOVPE on a GaAs substrate, bonded by direct adhesion and transferred onto insulator. The guides were then defined using electron lithography and dry etching [1] (fig 1.a). We used Fabry-Perot fringe contrast measurements [5] to assess propagation losses in the VOP-GaP guides at both pump and SH. The values obtained are higher than those measured in OP-GaP waveguides but remain competitive given the sub-micrometer dimensions of the guides. SHG is demonstrated at the wavelength expected for the TE00→TM10 process with a characteristic quadratic power evolution (fig 1.b). Our first measurements indicate a conversion efficiency competitive with other more matures photonic platforms like PPLN integrated waveguides [2].

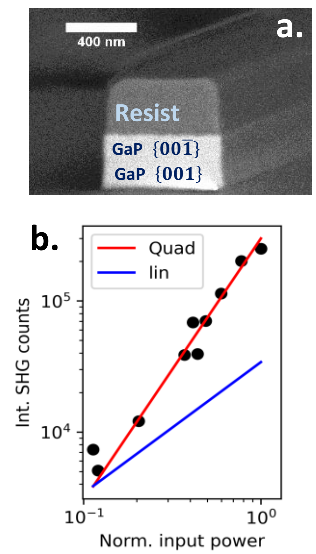

Fig.1.a. Vertical orientation patterned gallium phosphide (VOP-GaP) waveguide. b. Quadratic evolution of the SHG signal's power as a function of the input power.

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