Laser processing of amorphous Silicon on lithium niobate for photonic applications

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Silicon (Si) and lithium niobate ($LiNbO_3$) are two materials that are synonymous with the electronics and photonics industries respectively and are supported by a significant amount of technological know-how. It has been suggested and demonstrated recently that Si could also be used for the production of integrated photonic devices, however its performance can be limited by the transmission cutoff at short wavelengths, a relatively high two-photon absorption, and lack of second order nonlinear optical susceptibility. $LiNbO_3$ on the other hand is a very good dielectric material with high second order nonlinearity but with very little electronic functionality. It can be envisaged however that these two materials have complementary properties therefore there is significant merit in combining them into a single hybrid system that will benefit from the properties of its constituents as demonstrated in [1] on a directly bonded single crystal hybrid. In this contribution we will present results on laser processing of amorphous silicon films deposited on $LiNbO_3$ and other substrates suggesting a new route for the fabrication of Si based photonic circuits. This research is based on recent encouraging results of a laser based crystallization process obtained in a-Si core optical fibres that not only obtained crystallites with very large aspect ratio but also allowed for tuning of the Si bandgap [2].

This laser-processing route has been set out to deliver good quality poly-Si with large crystallites and low surface roughness in order to obtain good photonic and electronic performance. Interestingly it was revealed that, apart from the expected local crystallization of the a-Si film, this particular system exhibited a plethora of interesting and potentially useful effects including the direct formation of optical waveguides in $LiNbO_3$, and the modulation of the intrinsic coercive field.

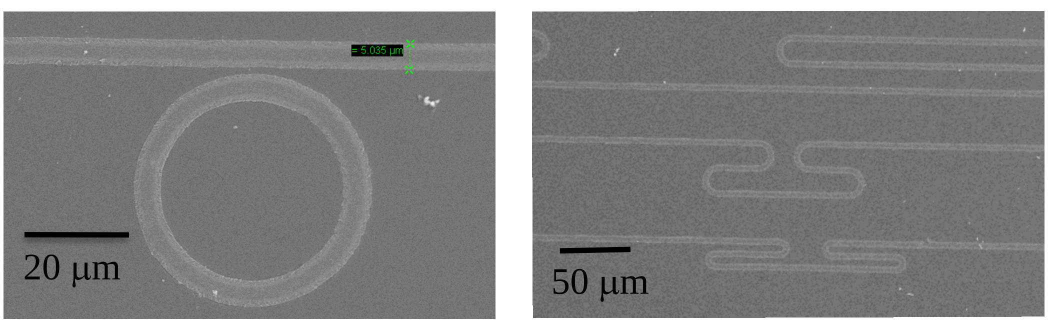

Figure 1. Spatially selective crystallization and differential etching for the production of poly-Si ridge waveguides

[1] J. Chiles and F. Sasan, “Mid-infrared integrated waveguide modulators based on silicon-on-lithium-niobate photonics,” *Optica*, vol. 1, no. 5, pp. 350–355, 2014.

[2] N. Healy, S. Mailis, N. M. Bulgakova, P. J. A Sazio, T. D. Day, J. R. Sparks, H. Y. Cheng, J. V Badding, and A. C. Peacock, “Extreme Electronic Band-Gap Modification in Laser Crystallized Silicon Optical Fibres,” *Nat. Photonics*, vol. 13, no. 12, pp. 1122-1127, 2014