A silicon/lithium niobate hybrid photonic material platform produced by laser processing

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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 a zero second order nonlinear optical susceptibility. $LiNbO_3$ on the other hand is a very good dielectric material with very little electronic functionality and high second order nonlinearity. Thus, as these two materials have complementary properties, there is significant merit in combining them into a single hybrid system that will benefit from the properties of its constituents, as demonstrated via direct bonding in [1]. Here we propose a route for producing such a hybrid material system via local laser processing of a low cost, easy to produce amorphous silicon (a-Si) film deposited onto a single crystal $LiNbO_3$ substrate. This research is based on recent encouraging results of a laser based crystallization process obtained in a-Si core optical fibres that not only produced crystallites with very large aspect ratios, but also allowed for tuning of the Si bandgap [2].

The emphasis of this laser-processing route has been on achieving structures with large crystals and low surface roughness in order to obtain good photonic and electronic device 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 $LiNbO_3$, enabled ferroelectric domain reversal and the spontaneous formation of periodic structural features on the Si film, shown in the figure below.

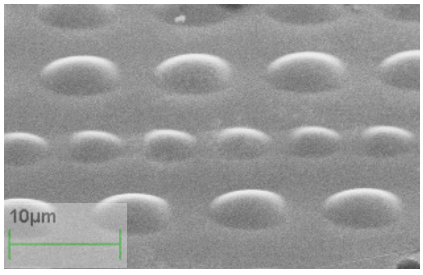

Figure 1. Periodic features on the Si film formed spontaneously during the laser processing

[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.