Development of polycrystalline silicon waveguides by laser crystallization

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Silicon (Si) is an excellent material for integrated photonics devices as its high refractive index allows for small device footprints. To date, most of the work in this area has leveraged the single crystal silicon-on-insulator platforms, which are relatively expensive to produce and thus drive up component costs. Here we propose an alternative method to fabricate crystalline silicon waveguides by laser processing of an amorphous starting material. As well as reducing production costs, this approach has the added advantage of removing the substrate dependence so that more flexible alternatives can be considered. This method has previously been applied to a-Si wires grown inside silica capillaries and shown to produce very large crystallites [1].

Here we demonstrate preliminary results of laser-induced crystallization of a-Si films and micro-patterned wires produced by chemical vapor deposition (CVD) on SiO_2 substrates. The samples have been crystallized using a c.w. argon-ion laser at 488 nm. Crystallized tracks have been written by scanning the focused beam across the samples using different laser intensities and scanning speeds. The resulting material quality is then studied using Raman spectrometry, optical and electronic microscopy and X-ray diffraction. For the planar films, we have produced crystallite sizes on the order of hundreds of nanometers to a few microns; similar to those obtained via conventional pulsed Excimer laser crystallization [2]. However, for the micro-patterned samples, we have found that it is possible to grow crystals that almost cover the entire width of the wire, over lengths of up to 18µm, considerably larger than what is typically reported for polysilicon waveguide devices [3]. Furthermore, this laser crystallization method has been observed to reform the surface of the Si wires resulting in very smooth sidewall profiles (as shown in Fig. 1) which is very important for low loss optical transmission in photonic devices.

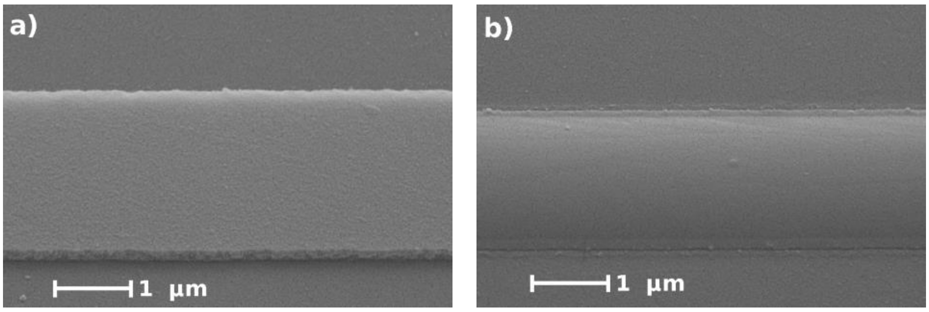

Figure 1. Silicon wire before (a) and after (b) laser crystallization process.

[1] Healy, Noel, et al. "Extreme electronic bandgap modification in laser-crystallized silicon optical fibres." *Nature materials* 13.12 (2014): 1122-1127.

[2] Preston, Kyle, et al. "High-speed all-optical modulation using polycrystalline silicon microring resonators." *Applied Physics Letters* 92.15 (2008): 151104.

[3] Ben Masaud, Taha, et al. "Hot-wire polysilicon waveguides with low deposition temperature" *Optics Letters* 38.20 (2013): 4030.