Sub-Micron Filamentary Structures Formed during Light Induced Frustrated Etching of Fe-Doped Lithium Niobate: Results and Modelling.

Jeffrey G. Scott, Alexander J. Boyland, Robert W. Eason

Optoelectronics Research Centre, University of Southampton, Southampton, SO17 1BJ, U.K.
e-mail: jgs@orc.soton.ac.uk

Lithium niobate is a versatile optical material with many applications that result from its wide range of electro-optic, nonlinear, photorefractive and piezoelectric properties. The ability to produce complex, yet controllable, aligned structures in lithium niobate without the need for photolithographic patterning, would allow the implementation of a range of applications such as Bragg and relief gratings, periodically poled structures, and miniature electro-optic devices.

The suppression of acid etching of iron-doped lithium niobate when illuminated with laser light was first observed by Barry *et al* [1] as an unexpected result when trying to actually enhance the rate of etching. With a sufficiently intense beam (at power densities > 100 W cm^{-2}) etching of the –z crystal face was seen to be completely stop. In areas that experienced a lower power density however, a partial frustration of etching took place. Scanning electron microscope (SEM) pictures showed densely packed and unusual micron and sub-micron-scale features that had developed in this region.

Further experiments have now been conducted to investigate these structures. The results show that the size and arrangement of the patterns formed depend on the concentration of the iron dopant within the crystal, the intensity of the laser beam at the particular location, and the duration of the etching process. Most of the structures tend to grow in one of three directions, matching the trigonal symmetry of the crystal. This is illustrated in figure 1, where a Fourier transform has been taken of an SEM picture, to show the preferred directions of the structures.

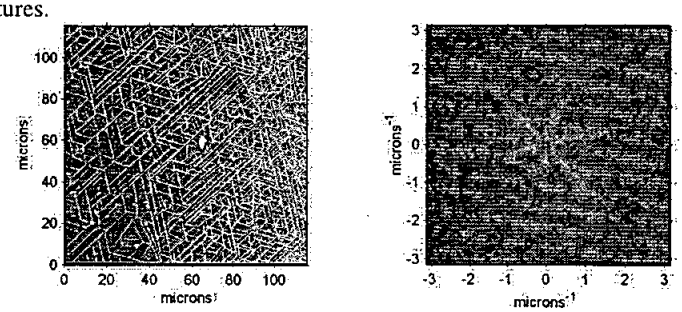

Figure 1: Scanning Electron Microscope picture and corresponding Fourier Transform

A simple model is also being developed, to reproduce the physical results and provide insight into the fundamental processes which are taking place. Figure 2 shows the result of a typical simulation which reproduces all the essential features observed in the experiment.

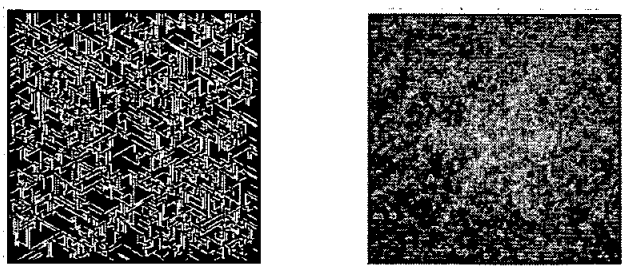

Figure 2: Model Results and corresponding Fourier Transform

This simulation had a starting grid of 1000 spots, which were allowed to grow according to a set of rules which have been deduced from the experiments. The Fourier transform of the simulated pattern shows a strong resemblance to that from the SEM image.

[1] Barry I. E., Eason R. W., Cook G., *Appl. Surf. Sci.*, **143**, (1999), 328

Large areas of sub-micron structures of variable density are formed during light induced frustrated etching of iron doped lithium niobate; we present the results and a model of this process and discuss future applications.