DEVIP-20

Focused ion beam technology for aligning and switching liquid crystals

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Focused ion beam (FIB) technology is an attractive tool for the fabrication of devices. A FIB unit consists of a finely focused beam of high energetic gallium ions and is used for milling and removing material from the top layer of a substrate. By moving the ion beam (in a similar way an electron beam of an electron microscope is scanned over the sample) it is possible to define almost any kind of structure with tolerances down to 10nm.

We used this FIB technology for defining alignment patterns for nematic liquid crystals. It is well known that well defined surface textures give the ability to control the alignment properties of the surface. On a scale comparable to the typical features of the texture, the liquid crystal director will deform in order to minimize the internal elastic energy. On larger scale, this influences the preferential direction and alignment strength of the surface. This allows for example to define and investigate structures that support multiple stable liquid crystal states.

The FIB technology gives almost full three-dimensional control of the geometry: by changing the milling time the etch depth is influenced, and by tilting the substrate one can even have a certain amount of controlled under-etching.

We present results of alignment structures fabricated in different materials that are common for liquid crystal technologies, including glass, ITO and silicon. We discuss the influence of the processing parameters, such as the ion energy and the beam current, and the effects of surface treatment of the fabricated structures.

The figure on the right shows a set of one dimensional alignment gratings with non-uniform pitch on an ITO-covered glass layer where the milling depth ranges between 100nm and 1µm. One can easily observe the differences in alignment quality.

We also used the FIB for defining the electrode structures. This allows for accurate positioning of the electrodes relative to the liquid crystal confining structures. In this way, we control the local electrical fields that switch the liquid crystal.

In conclusion, thanks to the versatility of the FIB technology we were able to fabricate new liquid crystal devices combining nanostructered alignment and electrode patterns.

Acknowledgements: Part of this research was carried out in the context of the European PICMOS and SAMPA projects, and the Belgian IAP PHOTON. Hans Desmet thanks the Fund for Scientific Research – Flanders, Belgium (F.W.O. - Vlaanderen).