Electrical Manipulation of Bubbles in Liquid Crystals

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We demonstrated that liquid crystals are uniquely effective host liquid to support foam structures because of the orientational order. We developed a T-junction microfluidics to generate uniform sized gas bubbles in liquid crystals for rapid production of liquid crystal foams. We report here that the bubbles generated can be flexibly manipulated by patterned electric fields to achieve sorting, transportation, patterning and foam draining.

The T-junction microfluidic device we developed generates approximately 20μm-diameter bubbles at a rate as high as 220 bubbles per second. The bubbles are ejected into a liquid crystal cell for further processing. Electric fields interact strongly with gas bubbles in liquid crystals for two mechanisms: orientational elastic effect that tends to expel bubbles out of electric fields; and dielectric forces that favor a higher dielectric constant material to segregate in electric fields.

An electric field method has been previously developed to sort colloidal particles in microfluidics [1]. In our work, we use patterned electric fields in microfluidics and in liquid crystal cells to manipulate the flow and arrangement of bubbles in liquid crystals. ITO layer on the glass is patterned by conventional photolithography method using a home-built maskless micro-optical pattern generator. Both dielectrophoretic and Frank elastic forces work and make the air bubbles in liquid crystals prefer to be in the electric field free area of a patterned ITO cell. The intensity of the electric field needed to efficiently manipulate bubbles in liquid crystals is studied. Different ITO patterns and voltage applying sequences can be used to serve different purposes including liquid crystal foam draining, bubble selection, patterning and transportation. Figure 1 presents the array of bubbles in liquid crystal confined by a grid patterned electrode. The image shown in figure 2 gives an example of a cell with a simple channel ITO pattern that confines and enhances the flow of bubbles in the liquid crystal, thus lowering the Ostwald ripening rate. We believe electrical manipulation of bubbles in liquid crystals can be efficient, versatile and useful.

References:

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