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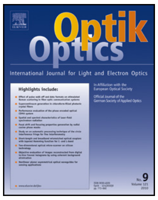

Fabrication and characterization of an electrowetting display based on the wetting–dewetting in a cubic structure

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ABSTRACT

In this article, a new and low-cost method for the fabrication of an electrowetting display is presented. A thin layer of PMMA was used as a dielectric on an electrode. Some 2 mm cubic holes, each representing one pixel of a display, were laser machined on a PMMA sheet and placed on top of the dielectric layer. The whole structure was then coated with fluoropolymer. The cubes were dosed with colored oil and the structure was placed in a saline environment. After applying electric potential between the electrode and the saline, water wetted the bottom face of the cubes and pushed the colored oil off the center, turning the transparency of a pixel from a minimum to a maximum. Computer simulations, the fabrication process, the dosing mechanism and the behavior of pixels in different electric potentials and their potential for displaying have also been investigated.

1. Introduction

Optofluidics is a science which deals with the manipulation of light with liquid mediums. In this field of study waveguides [1–4], light sources [5–7], lenses [8–10] and other optical elements are fabricated with liquids for different applications.

One of the advantages of liquid optical elements is their high tunability, which originates from the soft nature of these mediums. Different methods for manipulating the shape of a liquid medium can be found in literature, and electrowetting is one of the most promising methods among them. In this method, a droplet of a liquid is manipulated by applying an electric potential to a conductive liquid which is placed on a hydrophobic electrode [11,12] in various schemes [13] and in various micro and nano structures [14,15]. This manipulation technique has been used to fabricate several optical elements such as tunable lenses [16–18], tunable microprisms [19] and displays.

In display technology, electrowetting has been used in different structures to mimic the spreading of ink on a paper. Such displays offer low power consumption as well as high contrast with video-rate display ability [20–22] or at low speed [23].

In this article, a new structure for electrowetting display application is presented. The behavior of a droplet in a cubical hole with different wettability for the bottom face and the walls is investigated by computer simulation. A low-cost fabrication method is also presented which does not require any microlithography or plasma surface treatments, which are now used for some of the conventional electrowetting displays [24]. For display application, each cube is used as a pixel. The behavior of the pixels at different applied voltages and their switching times is investigated

2. Principle of the method

When a droplet is placed inside a wettable cubical hole without the top face, it tends to spread to the corners of the cube.

For a droplet which is small enough compared to the size of the cube, it fills the corners and leaves a nearly circular unwetted region at the central part of the bottom face of the cube. The size of this unwetted part depends on the volume of the droplet in the cube and the wettability of the bottom relative to the walls. Fig. 1 shows a computer simulation for a droplet in a cube without the top face, which has been performed by the Surface Evolver software [25]. In Fig. 1a–c, we assume that a droplet is placed inside a cube

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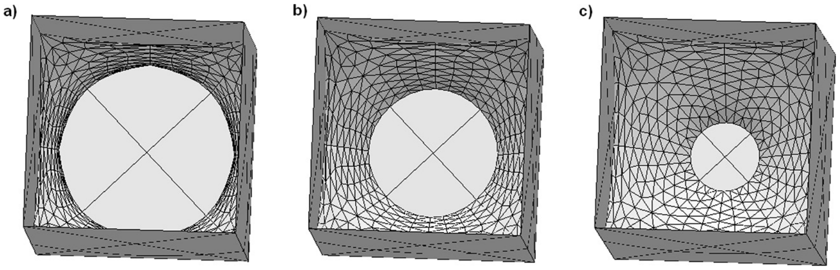

Fig. 1. Behavior of a droplet inside a cube without the top face as the volume of the droplet is increased. As seen in this figure, the droplet leaves a nearly unwetted region at the bottom face. Contact angle 50° on all surfaces.

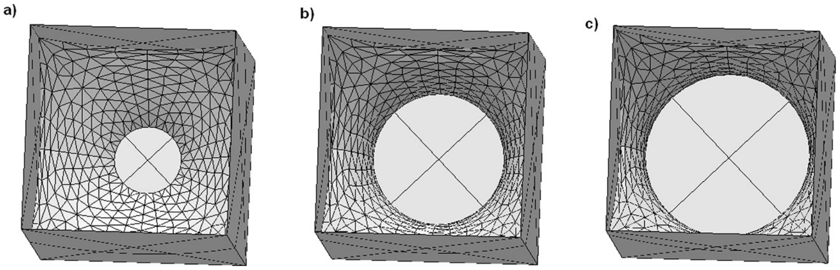

Fig. 2. Behavior of a droplet with fixed volume in a cube when its contact angle with the bottom face is (a) 50°, (b) 80° and (c) 100°. As seen in this figure, by decreasing the wettability of the bottom face, the droplet tends to clear the bottom face, leaving a larger unwetted region.

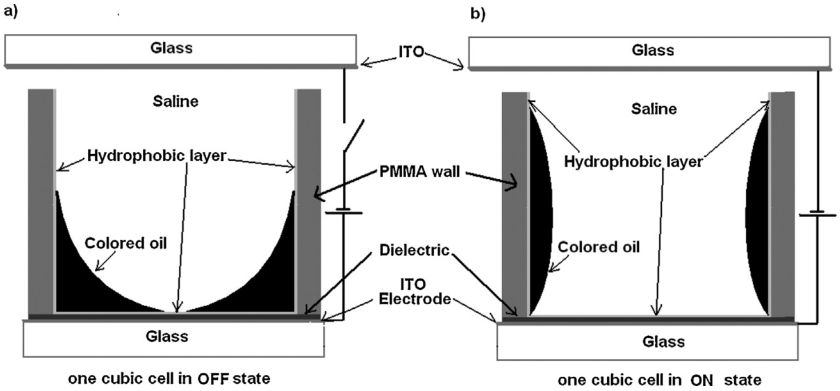

Fig. 3. (a) The designed structure for a cubic cell with optical switching ability. (b) By applying electric potential to the electrodes, the saline wets the bottom face and pushes the colored oil out.

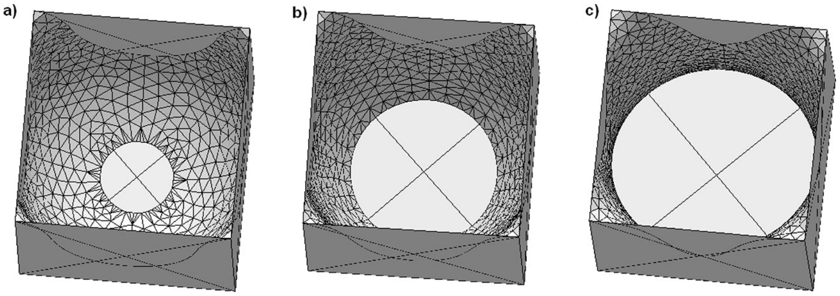

Fig. 4. The behavior of a droplet inside a cube with contact angle of 20° with the walls, when it's contact angle with the bottom face is (a) 20°, (b) 60° and (c) 100°. As seen, the droplet always remains inside the cube.

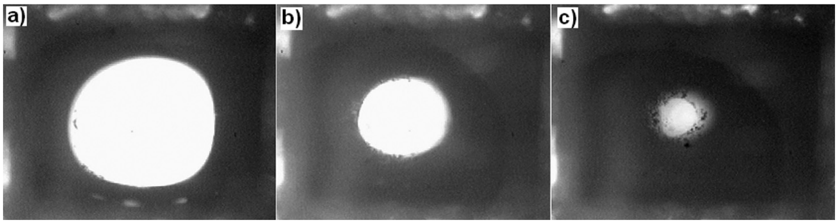

Fig. 5. One cell in a cubic array structure during the oil dosing.