ELECTROWETTING ON DIELECTRIC FOR BIOSAMPLE HANDLING USING ZnO AS HYDROPHOBIC MICROCHANNEL COVERAGE

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Abstract. *In this paper, we will review the electrowetting on dielectric (EWOD) principles applied to microfluidic devices. EWOD is the mechanism that can control wettability of liquids on solid surface using electric potential. In our case, we changed the teflon surface with ZnO transparent film in order to obtain a device with an optical weak absorption in the diapason ranged from VIS to far-MIR and THz waves. The microdroplet is manipulated by a microcontroller through contacts that are THz resonators at the same time. We control the moving speed and changing the pad interspacing by simulating the applied bias in Coventor software and calculated spectral analysis in Ansys for optimizing pad-THz resonator.*

Keywords: EWOD, *Electrowetting, Microdroplet, Microcontroller, THz, THz-TDS, Metamaterials*

I. Introduction

Electrowetting is the electrically induced modification of wetting properties of a conductive liquid on a surface. Since direct electrowetting which is based on a direct contact of the liquid and the electrode, can cause the electrolysis of the liquid before it makes significant contact angle change, an insulator is used to coat the electrode to prevent the electrolysis. This is called electrowetting on dielectric (EWOD) [1, 2].

II. Schematic diagram and device simulation

Figure 1a shows a schematic of the EWOD principle. When a voltage (V) is applied between the embedded electrode and the liquid droplet on the dielectric layer, the solid-liquid interfacial tension decreases and it reduces the contact angle from θ_0 to θ_V. Here θ_0 represents the angle between contact surface area and lateral surface of droplet at applied 0 volts, and θ_V after applied voltage (V) respectively (Fig 2a). If an array of the embedded electrodes is patterned, the droplet can move to the activated area when a partial area of the droplet base is activated by controlling a part of the embedded electrode array (Fig 2b, c). Then the EWOD device can be used to manipulate droplets for dispensing, transporting, splitting, merging, and mixing. For our project EWOD it was chosen a method to manipulate liquid droplets in digital (discrete droplet-based) microfluidics, however, the required voltage for driving a droplet has been several tens of volts to hundreds and hence various attempts we made to reduce the applied voltage by changing of the zinc oxide thickness [3]. At the same time it can serve an optical window for most of frequencies in the special for IR and THz that we are interested in.

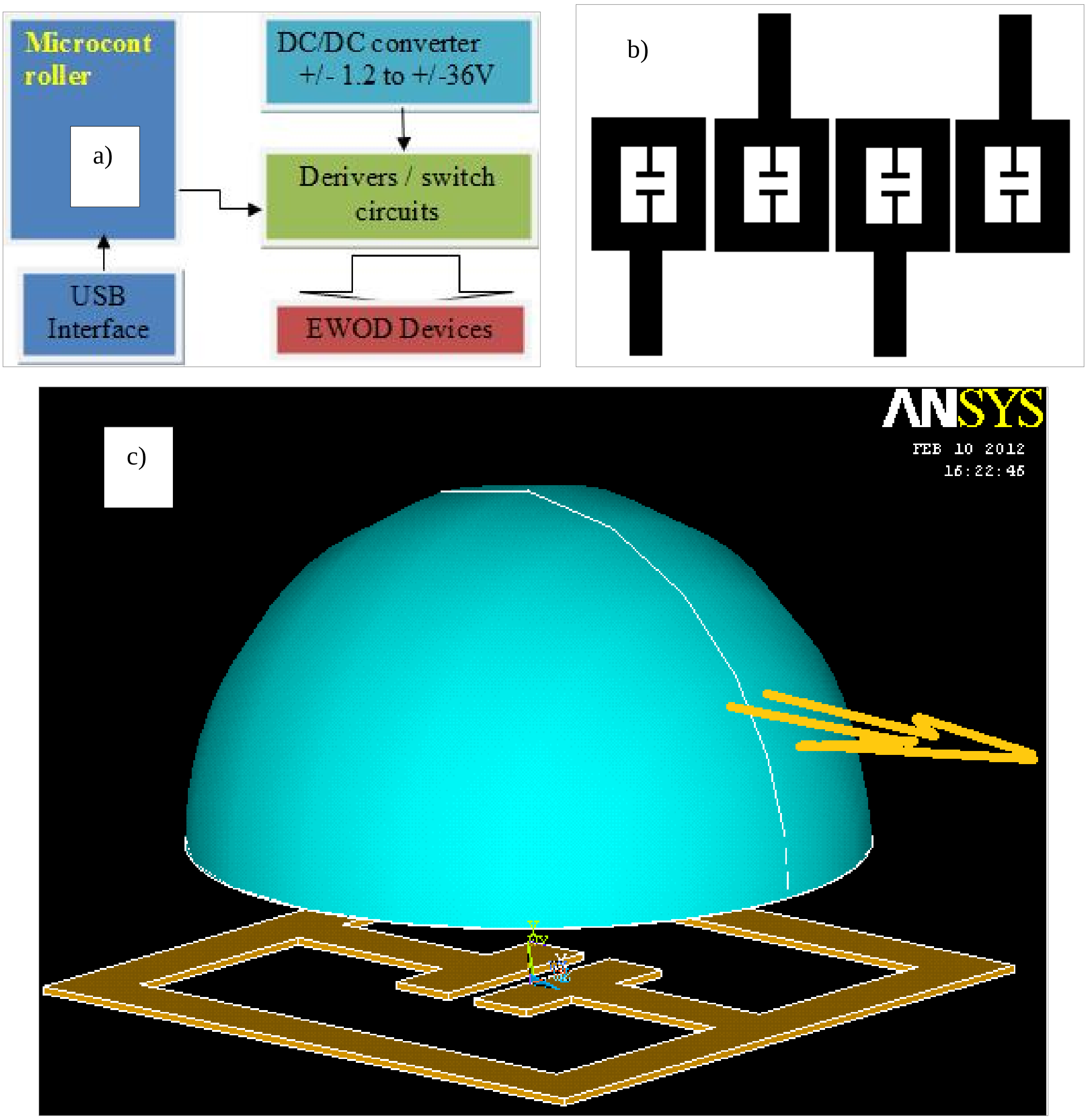

Fig.1 a) Block diagram of driving system for EWOD devices, b) Optimized EWOD THz-pad resonator based on metamaterial composites, c) direction of bio microdroplet over to the THz resonator.

Lippmann-Young equation shows the relationship between the contact angle change and the applied voltage through the dielectric layer, depending on the liquid-vapor interfacial tension and dielectric properties, as follows:

$$\cos q_V = q_0 + \frac{e_0 e_r}{2g_{lv} d} V^2 \qquad (1)$$

where e_0 is the permittivity of free space, e_r is the relative permittivity of the dielectric, g_{lv} is the liquid-vapor interfacial tension, and d is the thickness of the dielectric layer. According to this equation, a thinner dielectric layer with a high permittivity is desired to lower the driving voltage. This paper presents the fabrication and the driving characteristics of a low-voltage EWOD which was realized by using magnetron sputtering deposition of zinc oxide (ZnO).

Figure 1a presents a block diagram of the driving system developed. The driving system is designed to generate a square wave with voltages ranging from -15 V to15 V and frequencies up to 10 kHz and comprises an ATMEL microprocessor, drivers / switch circuits, a DC/DC converter and USB interface. The DC-to-DC converter utilizes two techniques. First is positive regulator IC LM317 and second is negative voltage generator with MC34063. The circuit includes a switch for each channel OPAM LM324 IC and is designed to switch the high positive and negative voltage signal produced by the DC-to-DC converter to the appropriate electrodes within the EWOD device in accordance with the control signals received from the microprocessor.

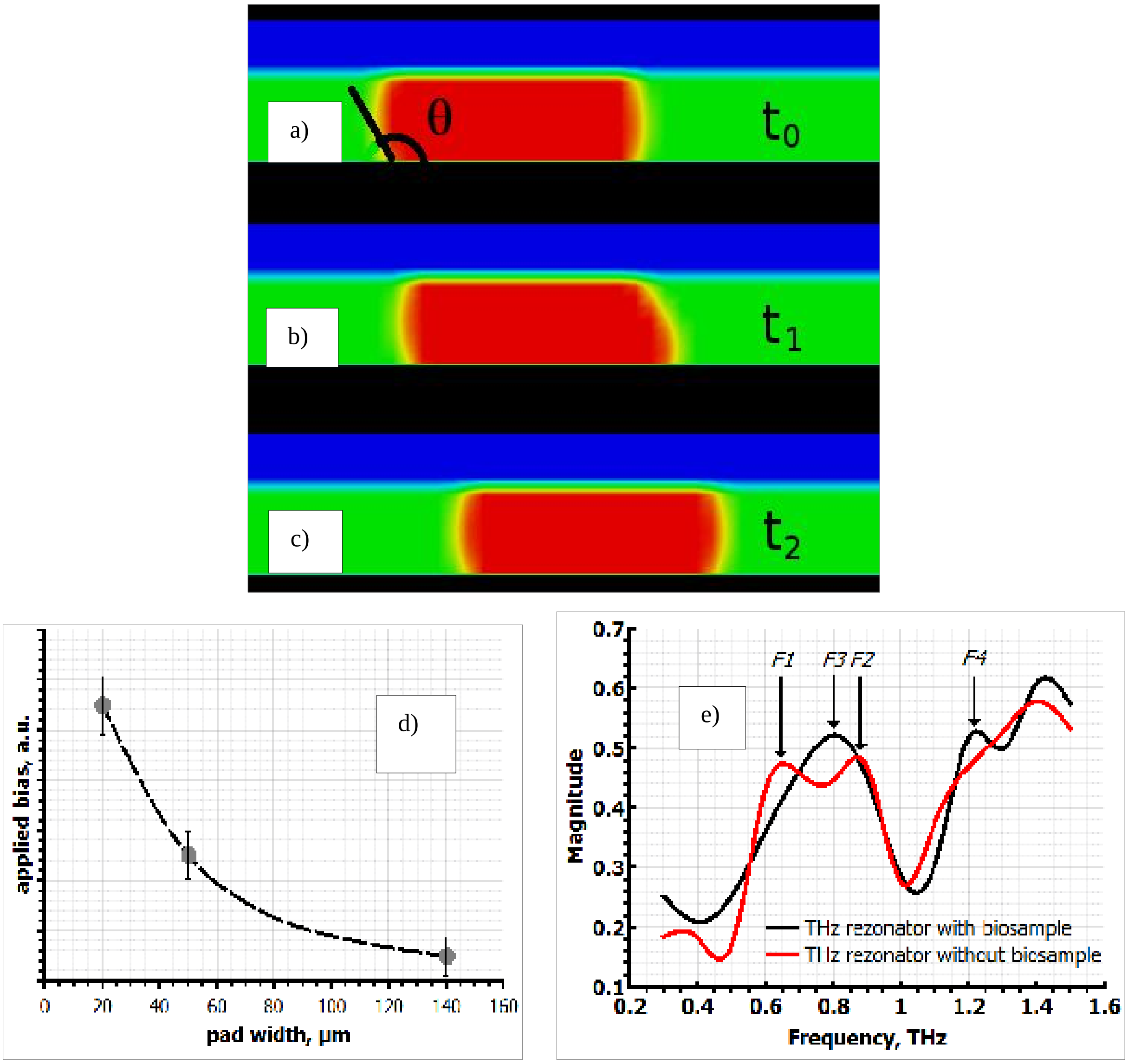

Fig 2. The moving of microdroplet inside of microchannel. a, b, c) position for time t_0, t_1 and t_2 respectively, d) applied bias on pads, e) spectral analysis for rezonator with and without biosample.

Metamaterials are sub-wavelength composites consisting of shaped metals and supporting dielectrics (Fig. 1b and 1c) which are capable of accessing regimes of electromagnetic response difficult or impossible to achieve with naturally occurring materials, such as negative refractive index, cloaking and quite generally, coordinate transformation materials design [4-6]. In connection with EWOD we can scan each microdroplet in real time mode by THz-TDS and identify the biomaterial that in t_0 time is situated on EWOD THz-pad resonator (Fig 2a). Figures 2a, b and c. represent the moving process inside of microchannel at position time t_0, t_1 and t_2 respectively. That is shown by markers F1 to F4 in THz spectra (Fig 2e). There are key frequencies for comparison between calculated resonators [4, 5] and for used biosamples.

III. Conclusion

We developed the pads for microchannel that at the same time can serve as reference resonators in THz frequency. In Fig. 2e, the values of markers F1-F4 can be used as a passport to distinct different types of biosamples. We demonstrated the possibility to fabricate a device that is able to handle with liquids, and to measure the THz spectra in real time.

IV. Acknowledgements

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V. References

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