Inkjet-Printed Piezoelectric Thin Films for Haptics

Sebastjan Glinsek, Longfei Song, Nicolas Godard, Mohamed Aymen Mahjoub, Stephanie Girod, Veronika Kovacova and Emmanuel Defay

Luxembourg Institute of Science and Technology
41 rue du Brill, L-4422 Belvaux, Luxembourg

ABSTRACT

Feeling surface texture of different objects is an important part of human interaction with the surroundings. While modern electronics recreate well visual and audio signals, texture-rendering technology is still in its early stage of development. In that context, surface haptics is emerging as the future of human-machine interaction.

Ultrasonically vibrating surfaces can modulate forces at the interface between a finger and a plate (see scheme in Figure 1a). For practical use, the out-of-plane displacement on the surface must exceed 1 µm, while the operating frequency must be above 25 kHz for silent operation. We recently demonstrated a fully transparent haptic device based on a piezoelectric thin-film technology, whose functional performances fulfil these conditions [1]. The cross-section of the device is shown in Figure 1a. Its main components are: fused silica (glass) substrate, piezoelectric Lead Zirconate Titanate (PZT) thin-film layer and interdigitated Indium Tin Oxide (ITO) electrodes.

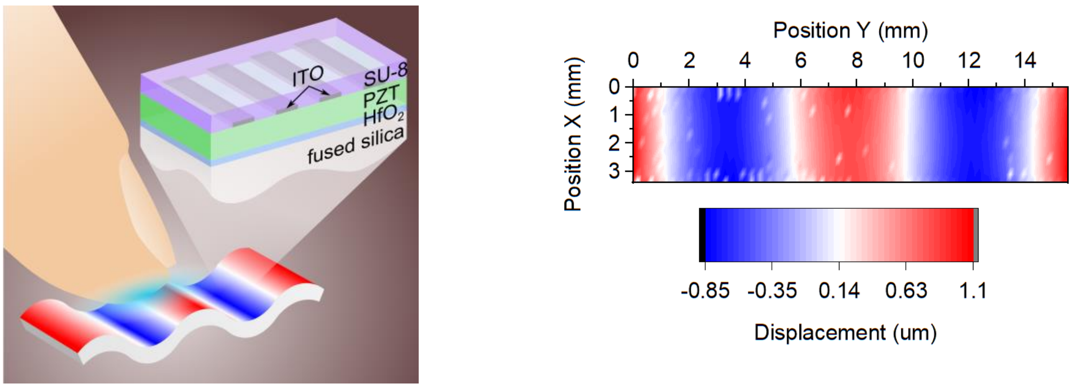

Figure 1: a) Schematic presentation of the ultrasonic friction-modulation principle. Cross-section of the device is also shown [1]. b) Inkjet-printed device: 2D map of the out-of-plane displacement measured at 63.2 kHz. The measurement was performed by applying 100 V unidirectionally.

Piezoelectric film was deposited using Chemical Solution Deposition (CSD). Deposition via spin-coating results in waste of most of the used solution and requires subsequent lithography steps to pattern functional structures, causing process to be expensive and often environmentally hazardous. On the other hand, deposition via inkjet printing drastically reduces material consumption and alleviates the need for cost-intensive lithography and etching steps. As we recently showed, it can be efficiently used to deposit high-quality PZT thin-film structures [2, 3].

In this contribution we will demonstrate that inkjet printing of piezoelectric oxides can be successfully implemented into the fabrication of transparent haptic devices. PZT structures, with width and length of 4 mm and 2 mm, respectively, were directly patterned on fused silica (glass) substrates. The films were ~1 μm thick and showed perovskite phase with preferential {100} orientation in X-ray diffraction patterns. ITO electrodes were deposited by sputtering.

Fabricated structures, with the size of 15.5 mm x 3.2 mm, were transparent and had transmittance of 72 % (at 550 nm). Performance of the device was tested in the ultrasonic range (63.2 kHz) using vibrometer and computer-controlled 2D stage. A standing A_0 Lamb wave is observed in Figure 1b, with out-of-plane displacement close to 1 μm. The result is comparable to the one obtained with a spin-coated PZT and demonstrates high quality of the inkjet-printed film. Processing, as well as detailed materials and device characterization, will be shown and discussed further in the contribution.

REFERENCES

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