UV-sensor based on capillary filled sub-micrometer interdigitated electrode arrays

Ethouba Al Jassin-Al-Hashemi[1,2], Barbara Horváth[1], Sijia Xie[1], Helmut Schift*[1]

Paul Scherrer Institut (PSI) [1], Lab. for Micro- and Nanotechnology, 5232 Villigen PSI, Switzerland
University of Basel [2], Department of Physics, Klingelbergstr. 80, 4056 Basel, Switzerland

E-mail: helmut.schift@psi.ch

Low-cost additive methods such as inkjet and gravure printing are favored fabrication processes for printed electronics, however, with resolutions often in the range much larger than 10 µm [1]. They are not suitable for large area electrode applications where sub-µm or even sub-wavelength resolutions are needed. Here, the deposition of nanoparticle inks on pre-patterned substrates is a solution [2,3]. If polymer substrates are imprinted with µm-sized grooves and reservoirs attached to them, then they can be filled from the side in an open-fluidics approach (Fig. 1). As has been shown with 2 and 5 µm wide grooves, convective effects enable to fill the grooves to a higher extend than would be predicted by the solid content of nanoparticle based silver ink. A much simpler approach is the spincoating of entire substrates of highly diluted inks (Fig. 2). While deposition on flat areas does not lead to dense coatings, within the grooves the nanoparticles form electrically conducting wires. With µm-sized V-grooves it was possible to confine spincoated silver particle-based inks down to 130 nm width from accumulated metal ink nanoparticles forming at the bottom of the grooves [1]. This is in the range of the nanoparticle size of ~50 nm that grow during sintering. The two methods, capillary filling and spincoating, can both be used for the fabrication of extended electrodes and wires.

Using this, we demonstrate the fabrication of UV-sensors based on an interdigitated electrode array (IDEA) with a 70 nm sputtered ZnO coating. The 1×1 mm^2 sensor area contained 100 wires in alternating directions that were electrically insulated from each other, and were attached to contact pads. Characterization of UV sensor devices was carried out experimentally by performing electrical measurements under UV light illumination (Fig. 3).

As substrates, we used replicas from V-grooves obtained by anisotropic etching of <100> silicon substrates in a potassium hydroxide (KOH)-based etchant. For the final replication the stamps were imprinted (T-NIL) into 175 µm thick films (PMMA: Evonik Plexiglas film 99524, T_g 113°C) at 180°C. Genes'Ink dispersions with silver nanoparticles with particle sizes <50 nm were used and further thinned down with different solvents. As UV-source, an unmounted LED was used with 355 nm (Lumex SSL- LXTO46355C) and 385 nm (Thorlabs M385F1) wavelength, and with an intensity of 0.080 and 0.087 mW/cm2, respectively, at the distance of 10 mm.

Combining nanoimprint lithography and additive patterning techniques may be a viable strategy to create low-cost devices on large areas. Such strategies can be applied to various designs of electrical circuits that enable to build complex devices as planned within the SFA project FOXIP [4].

References:

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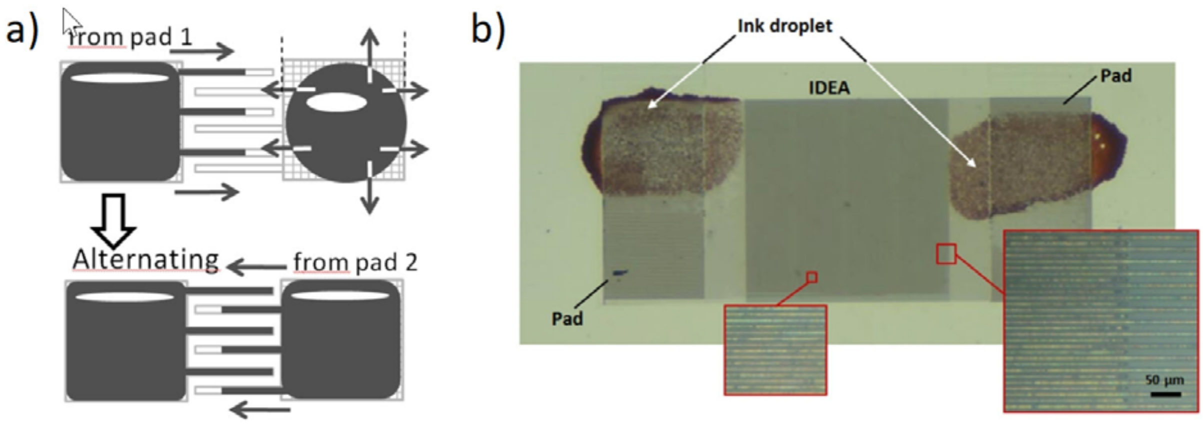

Figure 1. Interdigitated electrode array fabricated by capillary filling. a) Concept of droplet deposition on open capillaries between two pads. The schematic shows the filling sequence inking of the left pad and capillary filling, and inking of the right pad. b) Optical micrograph of a 1000×1000 μm^2 IDEA with 1.2 mm long electrodes attached to pads.

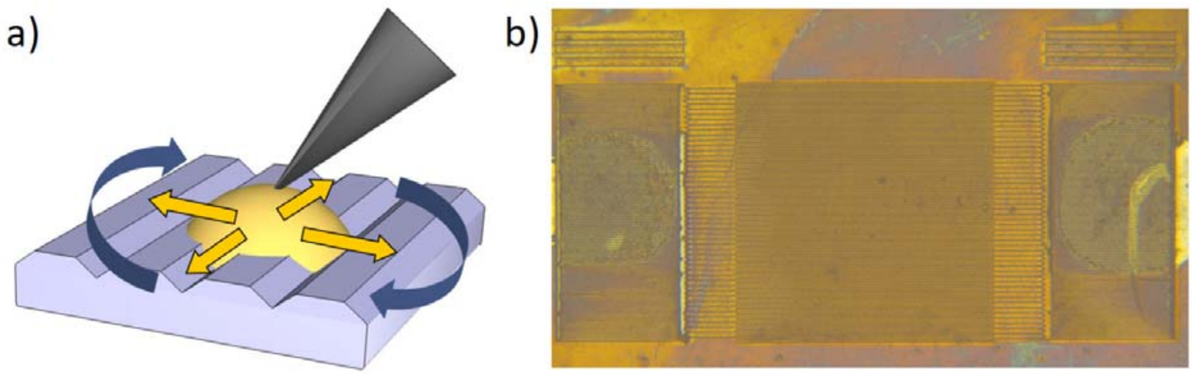

Figure 2. Interdigitated electrode array fabricated by spincoating. a) Concept of spincoating on V-groove patterned substrates. b) Optical micrograph of a 1000×1000 μm^2 IDEA with 1.2 mm long electrodes attached to pads, coated with ZnO.

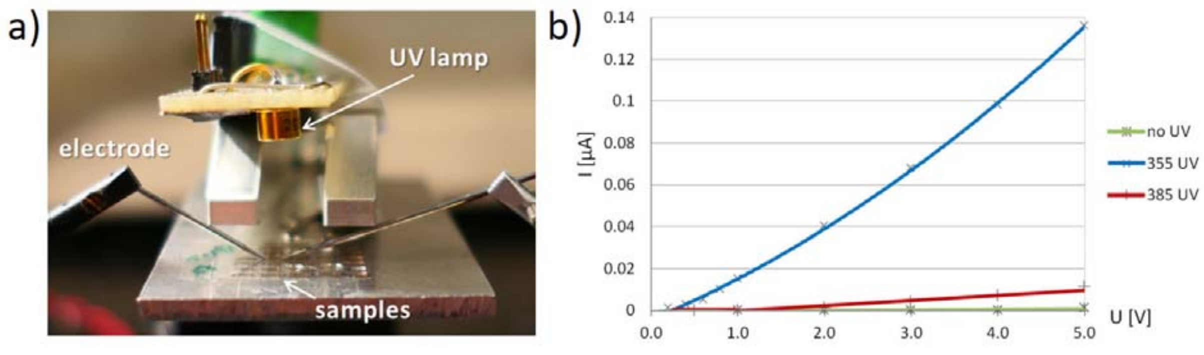

Figure 3. a) Photograph of the measurement setup with a film covered with IDEAs. UV lamp distance: 10 mm. b) I-V curve measured in dark and in UV irradiation of 355 and 385 nm.