Supplementary information

Reliable interfaces for EGaIn multi-layer stretchable circuits and microelectronics

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Supporting Material:

Ablation Angle
Estimation of Maximum Depth
Cross-sectional view of ablation
Dimensions of Tensile Specimens
Additional Tensile Tests
Cyclic loading test setup
Video: Demos

Ablation Angle of VIAs

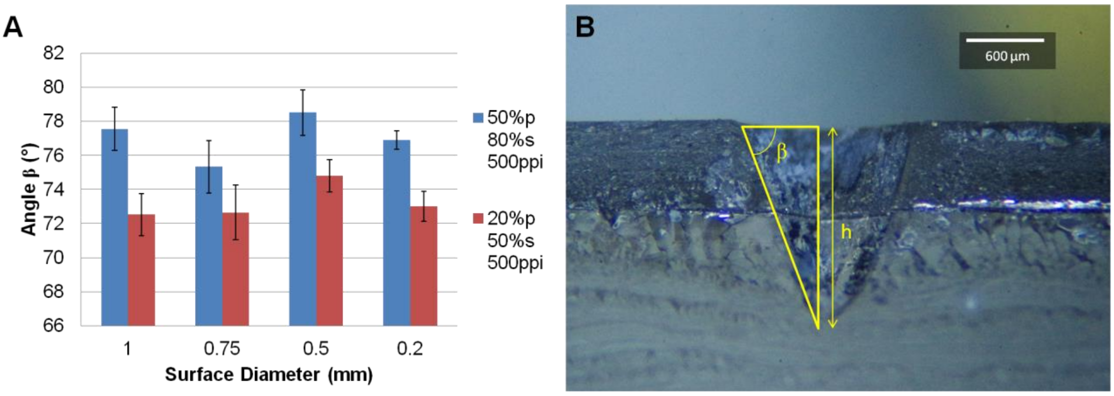

Figure S1 – A. Internal angle of ablation (*β*) in function of the surface diameter of ablation for two different sets of parameters of the laser printer (blue: 50%p 80%s 500ppi; red: 25%p 50%s 500ppi). The angle is approximately constant for each set of parameters, regardless of the surface diameter of the VIA. Lower ablation angles correspond to the ablation with a lower energy beam. **B.** Schematic drawing, on a microscopic cross-section photograph, of the triangle model to estimate, using simple trigonometry, the maximum depth (*h*) for a certain ablation angle.

Estimation of Maximum Depth of VIAs

β: Angle at the base of the cone

h: Depth of the Via

d: Surface diameter

σ: Standard deviation

$$h = \frac{d}{2} \tan \beta \qquad (1)$$

$$\sigma_h = \sigma_\beta \frac{d}{2} \frac{1}{\cos^2 \beta} \qquad (2)$$

Equation 1: Estimated depth *h* of ablation given the angle *β.*

Equation 2: Standard deviation of the calculated *h* based on the standard deviation of averaged *β* experimental measurements.

Cross-sectional view of ablation

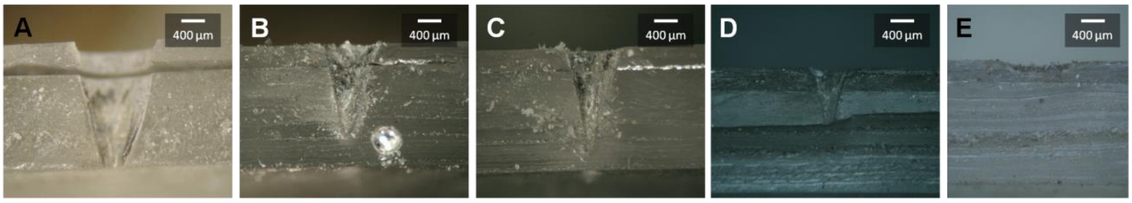

Figure S2 – Cross-section microscope view of the ablation of PDMS and EGaIn layer after 12 passes on the laser printer with 50%p 80%s 500ppi laser settings and for different surface diameters: **A.** 1 mm **B.** 0.75 mm **C.** 0.5 mm **D.** 0.2 mm. **E.** No ablation occurred with 5%p 15%s 500ppi and 1 mm of diameter.

Dimension of tensile specimens

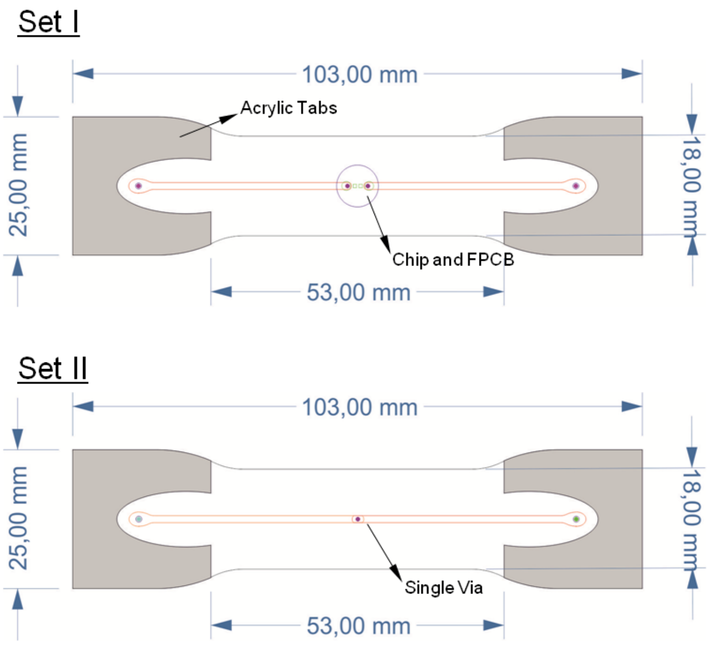

Figure S3 – Dimensions of the custom dog-bone shaped samples prepared for the electromechanical tests. As described in the paper, each sample has a conductive EGaIn trace between both ends of the sample, where an additional FPCB connector was attached (not shown in the picture). At the center of each sample: Set I has a 0 Ω resistor chip (YAGEO 0.063W, 1/16W Chip Resistor, 0402 packaging) soldered to a circular FPCB; Set II has a EGaIn VIA connecting the traces running from both ends of the sample; Set III (not shown in the picture), as a reference, has a single EGaIn trace between both ends of the sample. Thickness of the samples: 1.50 mm.

Additional Tensile Tests

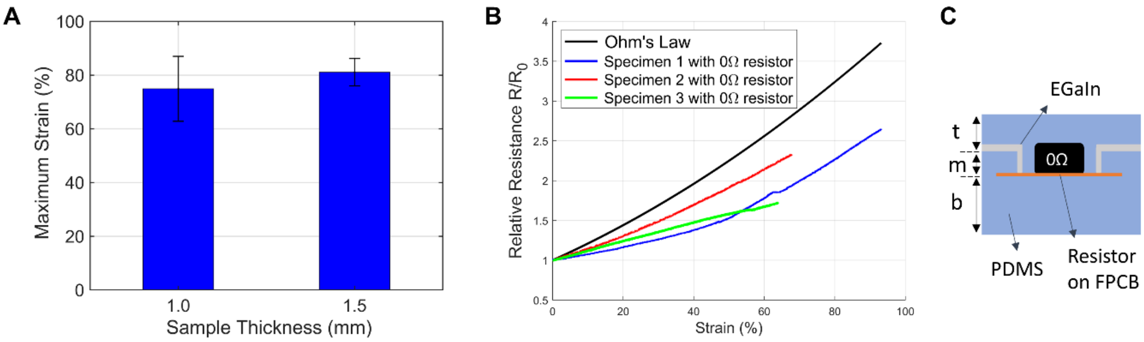

Figure S4 – A. Electromechanical tensile tests were performed on samples 1.0 mm and 1.5 mm thick. The results for maximum strain at break were 74.9 ± 12.1 % and 81.1 ± 5.1 %, respectively. **B.** Relative resistance of 1.0 mm thick samples with an interfaced 0Ω resistor chip on a flexible island. **C.** Side-view schematics of samples. *b*, *m*, and *t* refer to the respective PDMS thicknesses. For 1.5 mm thick samples: *b=750µm*, *m=250µm*, *t=500µm*. For 1.0 mm thick samples: *b=500µm*, *m=150µm*, *t=350µm*.

Cyclic loading electronic test setup

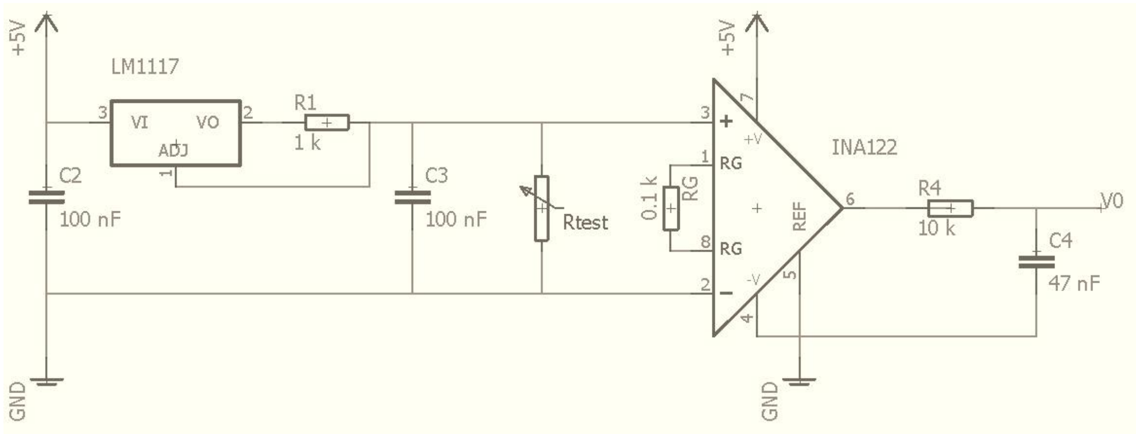

Figure S4 – Analog circuit to measure the variable resistance (R_{test}) of the sample and condition the signal input to the ADC of the microcontroller. Supplied with 5 V, a stage of constant current supply is composed by a LM1117 voltage regulator, as shown, and a resistor to fix the output current, which flows through the sample (R_{test}). Here, the voltage drop across the sample is measured with a INA122 instrumentation amplifier (single-supply, low input bias current, rail-to-rail output). High frequency noise is filtered with a low-pass filter (R4, C4) from the voltage output.