Supporting information for

Soft metal constructs for large strain sensor skin

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1. Compliant thin film model for stretchable rectangular gold thin films on elastic soft substrate

When the gauge axis is aligned with the uniaxial strain direction, the change in resistance of the gold track of length L, width W and constant thickness t under tensile strain ε is given by:

$$\Delta R_{2,ax.} = \rho\frac{L+\Delta L}{(W+\Delta W)\cdot t} - \rho\frac{L}{W\cdot t} = \rho\frac{L+\varepsilon L}{(W-\upsilon\varepsilon W)\cdot t} - \rho\frac{L}{W\cdot t} \qquad \text{(S1)}$$

where ρ is the constant resistivity of the metal layer and υ the Poisson's ratio of PDMS.

Hence :

$$\left(\frac{\Delta R}{R_0}\right)_{2,ax.} = \frac{\varepsilon(1+\upsilon)}{(1-\upsilon\varepsilon)} \qquad \text{(S2)}$$

When the gauge is oriented longitudinally relative to the uniaxial strain direction, the change in resistance of the gold track of length L, width W and constant thickness t under tensile strain ε is given by:

$$\Delta R_{2,trans.} = \rho\frac{L+\Delta L}{(W+\Delta W)\cdot t} - \rho\frac{L}{W\cdot t} = \rho\frac{L-\upsilon\varepsilon L}{(W+\varepsilon W)\cdot t} - \rho\frac{L}{W\cdot t} \qquad \text{(S3)}$$

Hence

$$\left(\frac{\Delta R}{R_0}\right)_{2,trans.} = -\frac{\varepsilon(1+\upsilon)}{(1+\varepsilon)} \qquad \text{(S4)}$$

2. Determination of the relation between the contact angle θ_c and the β coefficient

The area A of the truncated circle is defined by (see Figure S2)

$A = (\pi - \gamma)r^2 + \sin(\gamma)\cos(\gamma)r^2$ As $A = \beta\pi r^2$ and $\gamma = \pi - \theta_c$ then (S5)

$$\beta = \frac{\theta_c}{\pi} + \frac{\sin(2.(\pi - \theta_c))}{2\pi} \quad \text{(S6}$$

3. Determination of orientation angle ϕ_1 from angle θ in the rosette configuration

ϕ_1 is calculated from θ using the following algorithm [1]:

If $\varepsilon_A > \varepsilon_C$ then $\phi_1 = -\theta$.

If $\varepsilon_A < \varepsilon_C$ then $\phi_1 = -\theta + 90°$.

If $\varepsilon_A = \varepsilon_C$ and $\varepsilon_B < \varepsilon_A$ then $\phi_1 = -45°$.

If $\varepsilon_A = \varepsilon_C$ and $\varepsilon_B > \varepsilon_A$ then $\phi_1 = -45°$.

If $\varepsilon_A = \varepsilon_B = \varepsilon_C$ then ϕ_1 is indeterminate.

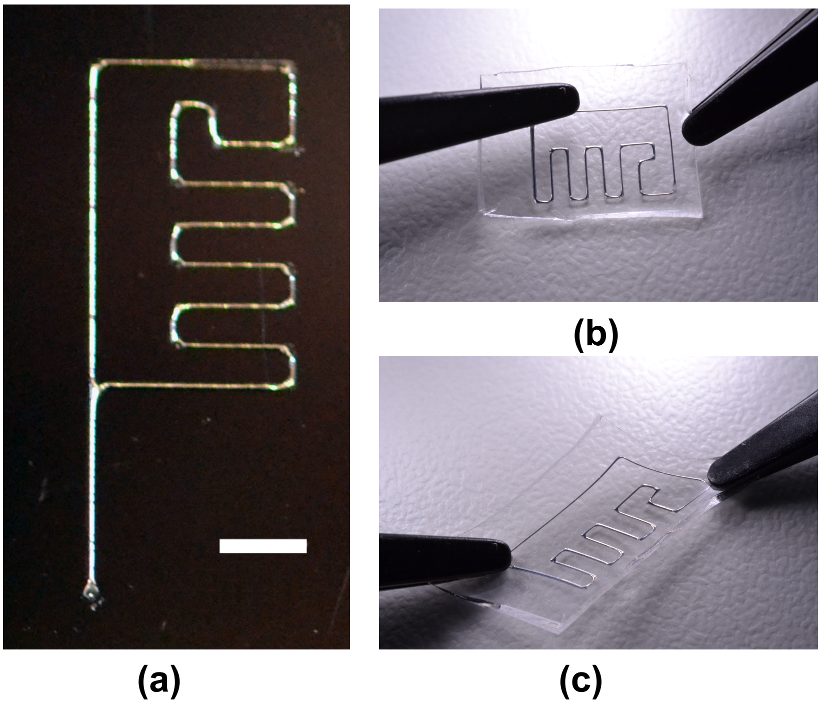

Figure S1: a) EGaIn pattern plotted on PDMS substrate. Scale bar is 2 mm. b-c) The encapsulated EGaIn structures are fully stretchable.

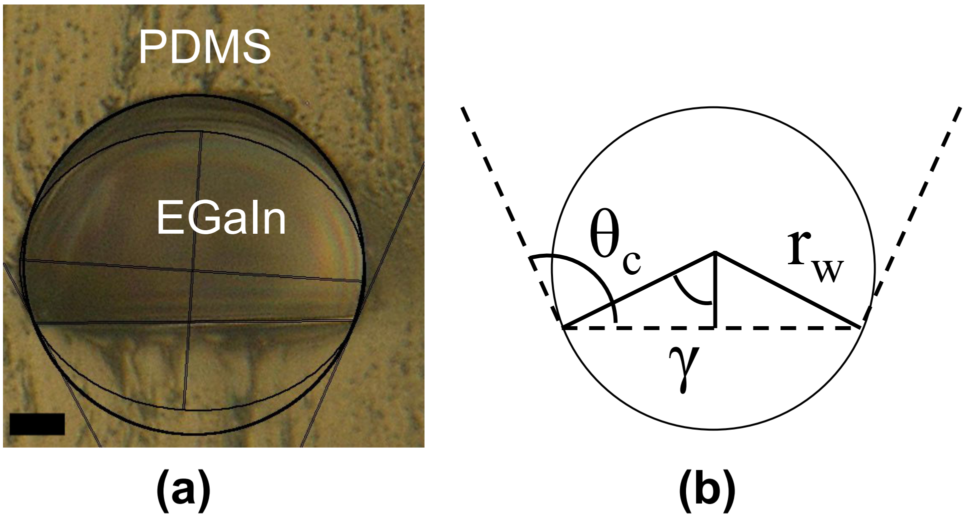

Figure S2: Cross section of a semi-cylindrical EGaIn micro-wire. Circle and ellipse best fit are plotted using Contact Angle plug-in for ImageJ with manual points procedure. In this example θ_c = 109°, corresponding to β = 0.7. Scale bar is 25 µm. b) Schematic for establishing the relation between θ_c and β (γ = 180°- θ_c).

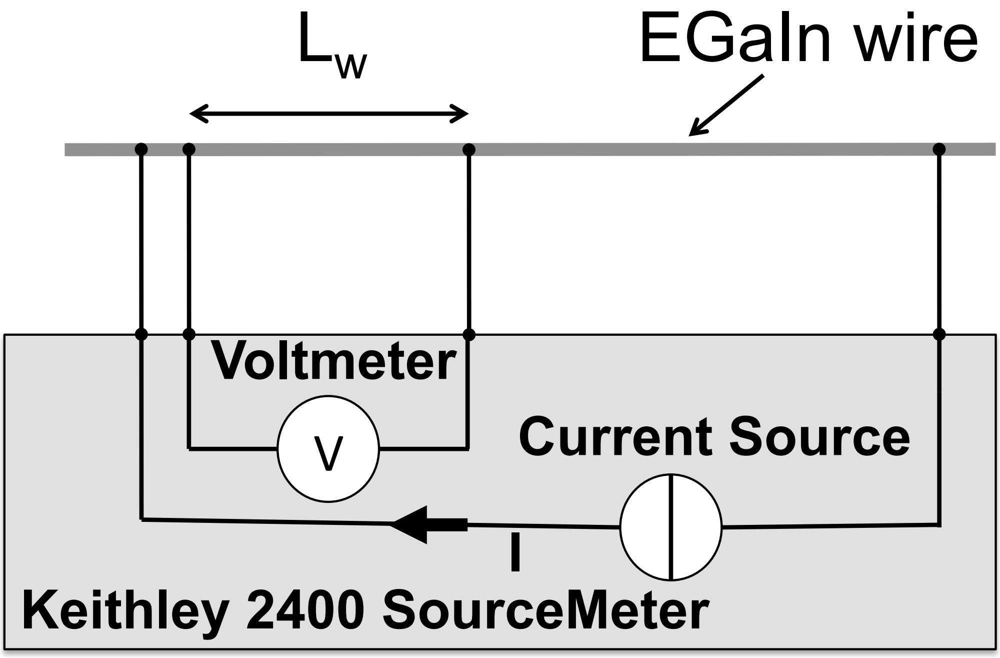

Figure S3: Set-up for the measurement of 4-wire resistance. L_w is the length of the section of the wire under measurement. The EGaIn wire is probed using solid Au wires.

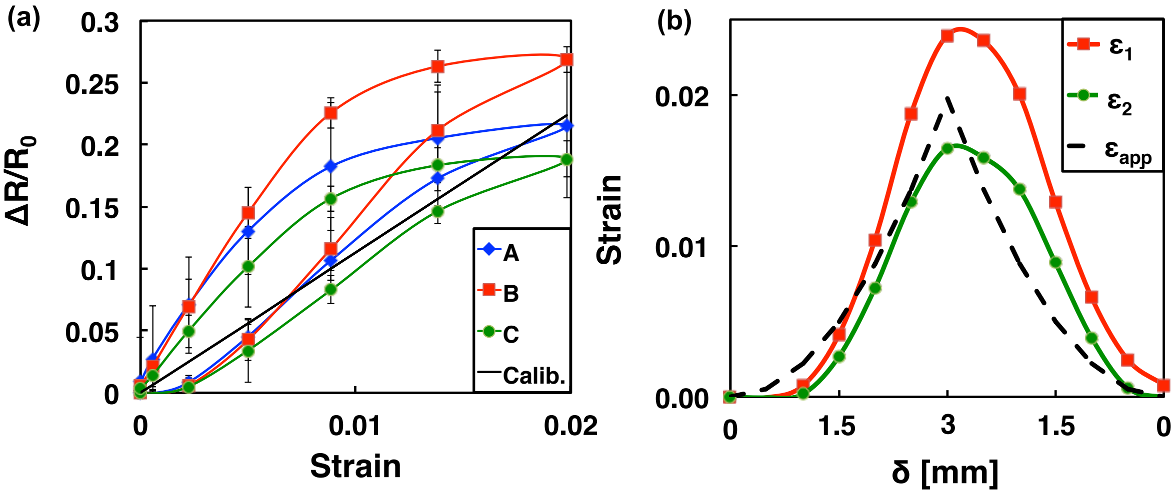

Figure S4: Response of a rectangular rosette under isotropic strain condition after six months storage in ambient conditions. (a) Relative increase in resistance of gauge A, B and C as a function of approximated applied mechanical strain. Errors bars represent 95 % confidence interval. (b) Magnitude of principal strains computed from the sensors' outputs as a function of indentation depth δ.

References:

[1]Perry. C.C. 1989 *Exp. Tech.* **13** 13-18