Stretchable Electronics

Jiajie Liang, Lu Li, Jake Hajagos, Xiaofan Niu, Zhibin Yu, Qibing Pei
Soft Materials Research Laboratory
Department of Materials Science and Engineering
University of California, Los Angeles
Phone: 310-8254217 Email: qpei@seas.ucla.edu

The emergence of devices that combine elasticity with electronic or optoelectronic properties offers exciting new opportunities for applications, but brings significant materials challenges. We will report (1) an elastomeric transparent conductor as a radically new electronic material for thin film stretchable electronics, (2) a highly flexible transparent capacitive sensor for the detection of deformation and pressure, and (3) an elastomeric polymer light emitting device, all by simple, all-solution based processes.

Transparent composite electrodes: We have introduced a facile approach to the preparation of polymer-based transparent conductor with surface conductivity and visual transparency comparable to those of indium tin oxide coating on glass and high mechanical flexibility including rubbery elasticity (Figure 1) [1-3]. The transparent conductor can be stretched repeated to greater than 100% strains without losing its electrical conductivity and mechanical integrity.

Elastomeric transparent capacitive sensors: Highly flexible transparent capacitive sensors have been fabricated employing a pair of compliant electrodes comprising silver nanowire networks embedded in the surface layer of polyurethane matrix, and a highly compliant dielectric spacer sandwiched between the electrodes [3]. The capacitance of the sensor sheets increases linearly with strains up to 60% during uniaxial stretching, and linearly with externally applied transverse pressure from 1 MPa down to 1 kPa. Stretchable sensor arrays consisting of 10x10 pixels have also been fabricated by patterning the composite electrodes into X-Y addressable passive matrix (Figure 2).

Stretchable Polymer OLEDs: An elastomeric polymer light emitting device (EPLED) have also been demonstrated employing a pair of elastomeric transparent electrodes to sandwich a layer of light emitting polymer admixed with a solid electrolyte [4]. The EPLED exhibits rubbery elasticity at room temperature, is collapsible, and can emit light when exposed to strains as large as 120% (Figure 3). It can also survive repeated continuous stretching cycles, and small stretching is shown to significantly enhance its light-emitting efficiency. The fabrication process is scalable and was readily adapted for the demonstration of a simple passive matrix monochrome display featuring a 5×5 pixel array.

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References

1. Z. Yu, Q. Zhang, L. Li, Q. Chen, X. Niu, J. Liu, Q. Pei, *Adv. Mater.* **2011**, 23, 664.
2. W. Hu, X. Niu, L. Li, S. Yun, Z. Yu, and Q. Pei, *Nanotechnology* **2012**, 23, 344002.
3. W. Hu, X. Niu, R. Zhao, and Q. Pei, Appl. Phys. Lette., 2013, 102, 083303.
4. J. Liang, L. Li, X. Niu, Z. Yu, Q. Pei, Nature Photonics, 2013, 3, 817.

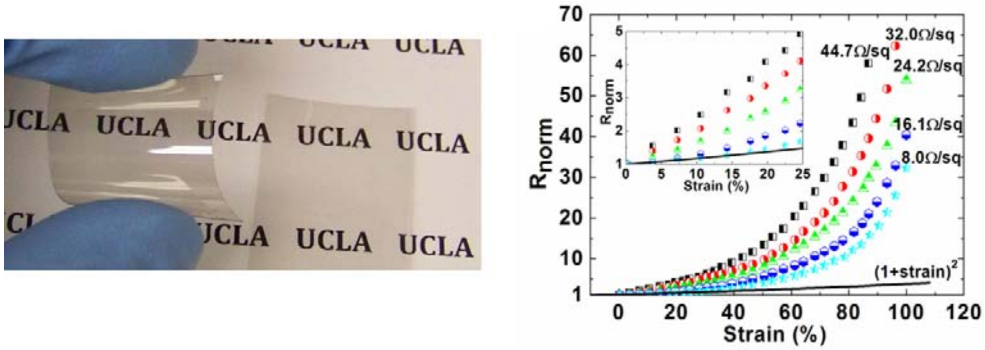

Figure 1. *Left*: Photographs of flexible transparent conductors. *Right*: Normalized resistance of conductors versus linear strain deformed at room temperature.

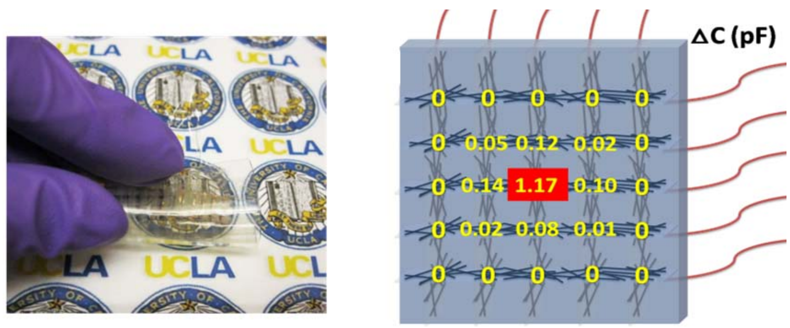

Figure 2. *Left*: Photograph of a pressure sensor array (10x10 pixels), each pixel being a square area of 1.5x1.5 mm^2 and separated by 1 mm from each other. *Right*: Mapping of the measured capacitance changes of pixels in the area where a pressure of 30 KPa was applied on the central pixel.

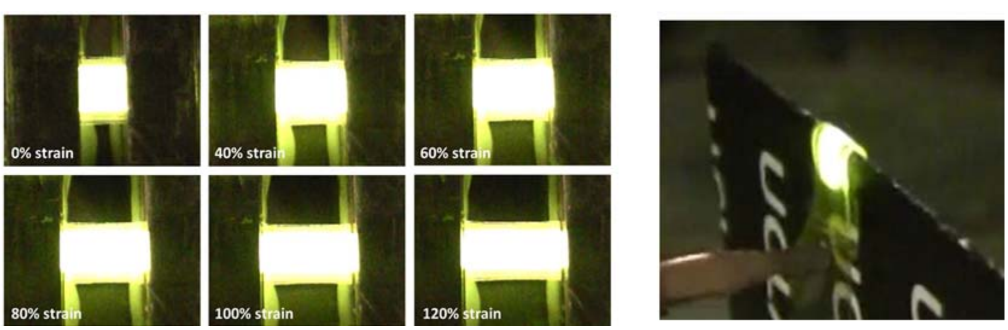

Figure 3. Left: Photographs of an elastomeric polymer light emitting device (original emission area: 5.0 mm × 4.5 mm) biased at 14 V at specified strains. Right: Another device (original emission area: 3.0 mm × 7.0 mm, biased at 12 V) wrapped around the edge of a piece of 400 µm thick cardboard paper. All measurements were carried out at room temperature.