Docket #: S15-217

Self-healing semiconducting polymer for flexible electronic devices

Researchers in Prof. Zhenan Bao's laboratory have developed an intrinsically stretchable and healable semiconductor polymer to fabricate high performance organic field-effect transistors for flexible and wearable electronic devices. These polymers contain building blocks with modified side-chains designed to both promote dynamic crosslinking after strain and maintain electrical performance when stretched. Even after 100 cycles at 100% applied strain, the polymers can return to their initial conductive activity because they only develop nanocracks which can be healed with an annealing process. Because the thin-film semiconductors do not require blending with elastomers for flexibility, devices made from these polymers can be fabricated with standard semiconducting processing technology. These polymers could be used to generate human skin-like organic electronic devices as well as other wearable electronics, flexible displays or solar cells.



Stretchable transistor as skin-inspired wearable device: *Stretchable transistor mounted on human limbs to test tolerance to various common movements that might be expected in a wearable device. The device maintains average mobility at >0.1cm^{2}V^{-1}s^{-1} under all these conditions.*

Stage of Research

The inventors have fabricated organic thin-film field effect transistors with these materials and demonstrated mobility as high as 1.3cm^{2}V^{-1}s^{-1} and high on/off current ratio exceeding a million. The transistors maintained performance with strains of 20-30% and recovered performance after being strained up to 100%.

Applications

- **Flexible and stretchable electronic devices** - polymer for applications such as:
  - wearable electronics
  - biosensors and bioimplants that require human skin-like materials
  - organic solar cells
  - flexible displays

Advantages

- **Stretchable and mechanically robust:**
  - maintains electronic performance with stretching up to 30% of initial length (the range required for most applications)
  - recovers electronic performance after strain up to 100%
- **High performance** - 1.3 square $cm^2V^{-1}s^{-1}$ and high on/off current ratio exceeding a million
- **Self-healing** - polymer bonds of semiconductor can be reformed to recover the initial mechanical properties using a heating and solvent annealing process
- **Standard semiconductor fabrication** - semiconductors are intrinsically flexible rather than relying on elastomers

Publications

- Oh, J. Y., Rondeau-Gagné, S., Chiu, Y. C., Chortos, A., Lissel, F., Wang, G. J. N., ... & Xu, J. (2016). Intrinsically stretchable and healable semiconducting polymer for organic transistors. *Nature*, 539(7629), 411-415.

Patents

- Published Application: 20170346013
- Published Application: 20180323376
- Issued: 10,050,203 (USA)
- Issued: 10,672,987 (USA)

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