Docket #: S17-155

Modular, flexible, self-healing sensor devices for wearable and internet-of-things applications

Engineers in the Zhenan Bao Research Group have developed a highly versatile electronics platform with individual modular building blocks that can be easily configured and reconfigured for a variety of applications. This multifunctional technology relies on a robust, flexible and stretchable elastomer that can easily form mechanical and electronic connections between sensors and a printed circuit board without soldering or adhesives. This self-healing feature allows users to customize a device for their particular application. In other words, they can “cut and paste” different sensors (e.g., temperature, pressure, luminescence, UV radiation, sound) together to perform complex functions that exactly match their needs. The resulting devices could be comfortably worn as a patch or a band. This single modular platform provides freedom of design for wearable electronics (including medical devices) or Internet of Things applications and could even be adapted for non-technical users in craft/hobby or educational kits.

Stage of Research
The inventors have synthesized a robust, stretchable, flexible elastomer material and demonstrated extremely high fracture energy (~12,000 J/m^2) with autonomous self-healing and notch-insensitive stretching up to 1200% due to efficient self-recoverable energy dissipation. They have fabricated a working prototype device that can be worn around the wrist or arm (see below).

Applications

- **Wearable Electronics** - customized sensors for consumer, medical or defense end-users

- **Internet of Things (IoT)** - customized sensors for monitoring assets, devices or robots
- **Art and Education** - modular sensors could be configured non-technical users for crafts/hobbies, STEAM education or customizable consumer electronics applications

Advantages

- **Modular design:**
  - individual building blocks for connecting sensors to a printed circuit board
  - customizable/tunable shape and functionality based on specific application
  - multiple sensors or other components can be easily configured and reconfigured, maintaining stable electrical connections without soldering or adhesives
  - single platform for both wearable and IoT applications
  - rapid prototyping
  - stacking and positioning of modules on 3D surfaces could enable a variety of new applications
- **Flexible and stretchable:**
  - comfortable and body compliant for wearable band or patch
  - extremely high fracture energy (~12,000 J/m^2)
  - notch-insensitive stretching up to 1200% due to efficient self-recoverable energy dissipation
- **Self-healing** - supermolecular structure of elastomer has a tuned ratio of strong of strong and weak cross-linking hydrogen bonds to promote self-healing
  - easily makes mechanical and electronic connections to add/subtract/reconfigure components
  - autonomously self-heals **under water**
  - robust against harsh conditions

Publications

- J. Kang, D. Son, O. Vardoulis, J. Mun, N. Matsuhisa, Y. Kim, J. Kim, J.B.-H. Tok, Z. Bao Modular and Reconfigurable Stretchable Electronic Systems *Advanced Materials Technologies* Dec. 21, 2018.

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