Development of functional materials for flexible energy harvesting devices and shortwave infrared photodetectors

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Printed electronic devices are attracting tremendous interest in both academia and industry because they enable facile integration of intelligent functionality into a wide variety of items, transforming them into smart objects for applications in packaging, healthcare, smart homes, and Internet of Things.

In my talk, I will first introduce our group's effort in developing novel materials and devices for energy harvesting via photovoltaic, piezoelectric, and triboelectric effects. The generated electricity is able to power miniaturized electronic devices and sensors for applications in smart homes and healthcare. The indoor OPV cells can deliver a power of 72 $\mu W/cm^2$ under LED light of 1000 lux, while the multilayer piezoelectric devices are able to output a high charge density of 376 $\mu C/m^2$ when bent under the bending radius of 20 mm.

In the second part of my talk, I will present our recent work on solution processed shortwave infrared (SWIR) photodetectors based on eco-friendly organic semiconductors and silver chalcogenide quantum dots. Photodetection in the second near-infrared (NIR-II) region of the electromagnetic spectrum is vital for many applications, such as bioimaging, environmental sensing, night vision, and safety surveillance. Currently, epitaxially grown InGaAs performs well in this spectral range, but its widespread deployment is hampered by its high manufacturing cost, rigidity, and limited form factor. Solution processed shortwave infrared photodetectors hold a great practical potential due to their low-cost, high throughput manufacturing methods, and facile integration with silicon readout integrated circuits. To achieve photoresponse beyond 1100 nm, we have developed a series of low bandgap polymers with strong internal D-A interaction. One polymer exhibited a high specific detectivity of ~10^{11} Jones at 1200 nm under −1 V bias owing to its significantly low dark current. Silver chalcogenide colloidal quantum dots (CQDs) are promising hazardous-metal-free nanomaterials. Our group have optimized reaction conditions to synthesize Ag_2Se and Ag_2Te CQDs with good colloidal stability, narrow size distribution, and good photoluminescence quantum yields. Ag_2Se based devices showed a responsivity of 4.17 mA/W and an on/off ratio as high as 490 under 1 mW/cm^2 illumination at 1200 nm. Ag_2Te extended the device's photoresponse range to 1400 nm.