Fabrication and Characterization of Polymer-based Organic Electronic Devices for Healthcare Applications

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In this dissertation, we have reported the fabrication and characterization of low power, polymer-based organic electronic devices for various sensing applications. Most of the devices are flexible in nature and are suitable for wearable applications. We have utilized polar dielectric materials as a sensing layer of the organic field-effect transistors (OFETs) based devices. We also have used polymers or polymer nanocomposite materials as sensing layers in the few two-terminal devices. Hexagonal barium titanate nanocrystals (h-BTNCs) in the amorphous matrix have been synthesized as temperature-sensitive materials and has been utilized together with alumina as bilayer dielectric system for the fabrication of flexible, low voltage, ultra-fast OFETs based temperature sensors. The working temperature range for these devices is from 25 ºC to 50 ºC and found to be suitable for health care applications to monitor body temperature continuously. The typical response and recovery times are about 24 ms and 51 ms, respectively. In another work, we have employed gelatin as a humidity sensing material and have developed asymmetric metal electrodes (Cu/Gelatin/Al) based a moisture-induced flexible energy harvesting device, which can generate electric power up to 5.5 $\mu W/cm^2$ at 90%RH. These devices have been used as self-bias humidity sensors to monitor breathing profile, respiratory rate, and lateral mapping of the moisture level of human skin for different healthcare applications. Apart from this, the devices have been demonstrated as self-bias humidity dependent electronic switches. In addition, the gelatin films with alumina have been used as a suitable bilayer dielectric system to fabricate high-performance, low power consuming flexible OFETs. The devices showed about 10^3 times increase in device current due to the change in humidity level from RH 10% to RH 80%. The sensitivity of the devices has shown a gate bias dependency with a maximum sensitivity of 2185. Chicken albumen, which is a biopolymer, has been used to fabricate OFETs based portable UV sensors systems. Here, we employed the temperature-induced self-crosslinking effect of albumen to achieve better device performance in a low operating voltage of 1.5 V. The highest mobility of the devices is 3.5 (±0.4) cm^2/Vs. We have addressed the overestimation of carrier mobility for the OFETs fabricated with polar or ionic dielectric systems. The devices showed a maximum responsivity and detectivity of 0.084 A/W and 7.6×10^{10} cm $Hz^{1/2}$ W^{-1} for UV-light absorption. These devices are suitable to detect minimum erythemal dose (MED) for UV-A for human skin. Finally, we have synthesized silver nanorods and have made a composite with PEDOT: PSS to fabricate strain sensors, which work within the range from 0% to 180%. The strain sensors have been demonstrated for monitoring blood pulse profile, heart rate, and the detection of human body parts.

Keywords: organic field-effect transistors, flexible sensors, temperature sensors, humidity sensor, UV sensor, self-powered sensors, silver nanorods, flexible energy harvesting device, protein-based devices, low-power OFETs, electronic skin, healthcare sensors, overestimation of carrier mobility.