Abstract and Keywords

In this dissertation, we have reported the fabrication and characterization of organic electronic devices for high-performance biomolecules and light sensing. We have developed organic field-effect transistors (OFETs) as biosensors for sensing (i) human serum albumin (HSA) proteins in blood samples, (ii) SARS-CoV-2 virus present in saliva samples, and also (iii) blue light sensors. The top contact bottom gate OFET with bilayer dielectric ($Al_2O_3/BaTiO_3$) and pentacene as a semiconducting channel have been used. In biosensors, we have used a newly synthesized trichromophoric pentapeptide (**TPyAlaDo-**Leu-ArTAA-Leu-**TPyAlaDo**, TPP) molecule for sensing of HSA protein and commercially available angiotensin-converting enzyme 2 (ACE2) for sensing of S1 protein of SARS-CoV-2 virus. In the development of these sensors, we have studied the growth mechanism of the TPP layers on pentacene. The molecules diffuse into the grain boundaries when the sensing material is coated on the pentacene film. We have observed compressive residual stress developed in the pentacene films upon diffusion of TPP molecules into the grain boundaries. As a result, the thin film crystallographic phase of pentacene films degraded. The strain has been engineered by controlling the thickness of TPP films so that the bulk crystallographic phase is not damaged, yet, the TPP molecules can easily get access the conducting pathway at the semiconducting/dielectric interfaces of the OFETs. As a result, we observed high performance in detecting HSA protein levels in the blood. The sensors can detect an ultra-low blood albumin concentration and cover a wide detection range from 1 pM to 1mM. This sensor is suitable for detecting HSA levels directly from blood samples, enabling it for point-of-care (PoC) applications. The typical response time for sensing of HSA level is less than 3 minutes. In the second work, we have fabricated an ultra-fast and low-power consuming antigen-based sensor system for detecting the SARS-CoV-2 virus collected from the saliva sample, which is also suitable for PoC testing. The unique features of our device include ultra-fast detection time (< 1 min), and the highest sensitivity (94%), which is the highest reported value. As the sensors work with saliva, they enable easy and safe sample collection and reduce the complexity of traditional sample collection using cotton swabs. In addition, we have developed an Android app-connected sensor module, which is suitable for large-scale testing with immediate testing results. To explore the effect of dielectric materials as a sensing layer, we have developed blue light sensors using the same OFETs platform. However, we have used a metal halide inorganic perovskite $CsPbBr_3$ as suitable sensing dielectric material to fabricate high-performance, selective, and low-power consuming flexible OFETs-based sensors. Perovskite has strong absorption of blue light, which generates a huge number of photocarriers. These carriers are accumulated at the dielectric/dielectric ($Al_2O_3/CsPbBr_3$) interface and form a large dipole, resulting in increases in polarization. The devices show high selectivity towards blue light compared to other light in the visible light spectrum.

Keywords: organic field-effect transistors (OFETs), human serum albumin (HSA), angiotensin converting enzyme (ACE2), SARS-CoV-2, COVID-19, pizoresponse force microscopy (PFM), metal halide perovskite (MHP).