Organic Photodiode for Biometric Application System

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論　文　内　容　の　要　旨
Thesis Summary

Recently, smartphone makers are increasingly opting for a bezel-less display, eliminating the need for a fingerprint sensor on the home button. Thus, a thin-film fingerprint sensor within the display area would be an appealing option, despite the development of ultrasonic and thermal fingerprint sensors. Both have disadvantages: ultrasonic sensors are expensive for large-area display applications, and thermal sensor pictures have a short lifetime. Therefore, an optical fingerprint sensor based on solution-processed organic photodetectors (OPDs) could be used as an alternative. The OPDs based on organic semiconductors are a potential class of sensors that can provide these features. Their performance has increased rapidly in recent years, demonstrating their potential as a supplementary technology to inorganic devices. Most importantly, their solution processability allows for fabrication using industrial printing processes. The significant parameter space of printing, along with the morphological and energy requirements of OPDs, creates a slew of obstacles to the transition from lab-scale to applicable production procedures.

However, there are still several issues related to the reliability of the optical fingerprint sensor, especially identity spoofing. On that account, several studies have been done recently to employ the Photoplethysmogram (PPG)-based authentication, which utilized the time-series bio-signals for biometrics. From this perspective, this dissertation provides a fundamental analysis of the optical simulation for human skin structure and fingertip structure at different distances and positions between the light source and detector for PPG sensor application. This analysis is done to understand the light propagation behavior in human tissues for better detection of PPG sensors. The simulation results show that the reflectance-based PPG principle has higher detection than the transmission-based principle. Plus, the reflectance-based is better in terms of applicability to any body parts.

Then, this study proposed the fingerprint-on-display (FOD) applications based on OPD devices for the biometric sensing application for the smartphone. This system uses the pinhole imaging technique, well-known for its immense images and straightforward structure. It combines optical sensors, which serve as image sensors, with a display for biometric fingerprint scanning. There are a few options for integrating this feature across the display area. Compared to inorganic photodiodes, OPDs benefit from large-area deposition capabilities, which can cover the entire display sensing area. The light distribution from a pinhole onto the sensor pixel was studied to observe the crosstalk and uniformity. Thus, recommending the critical parameters to improve the system in the future.

The evaluation focuses on the optical crosstalk between adjacent pixels for the organic image sensors using the interdigitated electrode structure. For applications requiring full-display sensing, the shorter exciton diffusion length of organic semiconductors in the OPD can support the high resolution of the organic image sensor. By adjusting the distance to determine the

minimum pixel pitch for the organic image sensor, we could demonstrate the photocurrent diffusion from the exposed area to the buried electrodes. Unexpectedly, the observation shows that the photocurrent diffusion was more critical than the anticipated exciton diffusion length, even at 10 μm.