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Monolithic Integration of Organic Electronic Devices

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A novel organic optical sensor that integrates a front organic light-emitting diode (OLED) and an organic photodiode (OPD) is demonstrated. The stripe-shaped cathode is used in the OLED components to create light signals, while the space between the stripe-shaped cathodes serves as the detection window for integrated OPD units. A MoO3 (5 nm)/Ag (15 nm) bi-layer inter-electrode is interposed between the vertically stacked OLED and OPD units, serving simultaneously as the cathode for the front OLED and an anode for the upper OPD units in the sensor. In the integrated sensor, the emission of the OLED units is confined by the area of the opaque stripe-shaped cathodes, optimized to maximize the reflected light passing through the window space for detection by the OPD components. This can ensure high OLED emission output, increasing the signal/noise ratio. The design and fabrication flexibility of an integrated OLED/OPD device also has low cost benefits, and is light weight and ultra-thin, making it possible for application in wearable units, finger print identification, image sensors, smart light sources, and compact information systems.

Organic electronic devices have been developing rapidly and significant progress has been made in organic light emitting diode (OLED) displays, white OLED lighting, organic transistors, organic photodetectors (OPDs), and organic solar cells. Compared to those devices based on inorganic semiconductor materials, which still play a major role in the optoelectronic market, the emerging organic electronic devices offer additional advantages such as large area, flexibility, and solution-based fabrication processes at low costs. Thin film organic optoelectronic devices offer an attractive option for achieving flexible organic electronics. Organic semiconducting materials as the active components in the devices have many advantages, e.g., thin, lightweight, large area, cost effectiveness, chemical tenability, and mechanical flexibility. A variety of organic optoelectronic systems are being explored for application in organic photonics in communication, all-polymeric optocouplers, chemical sensing, biosensing, refractometers, memory, and optical integrated systems. The multilayer organic optoelectronic devices such as multiphoton emission devices, tandem organic solar cells, and OPDs with external quantum efficiencies up to 75% across visible light and bandwidths approaching 450 MHz have been reported. A typical organic sensor consists of an OPD integrated with an OLED. The integration of OPD with OLED in a stacked geometry results in better light coupling from OLED to OPD compared with that between discrete devices. The integrated organic optical bi-functional matrix arrays and bi- stable optical switches have been demonstrated. An integrated organic functional device utilizing OLEDs and OPDs for optical interconnection with high-speed transmission and flexible optical circuits was also reported. However, the existing organic sensors have limited flexibility to achieve monolithic integration of organic electronic components for application in large area imaging sensors at low costs. In this work, we report our effort to develop a novel organic optical sensor that monolithically integrates a front OLED and an OPD. The design and fabrication flexibility provided by the material and process could readily construct multilayered organic optoelectronic systems for application in wearable units, finger print identification, image scanners, position scanners, smart light sources, and compact information systems.

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