

論文の内容の要旨

論文題目

Highly sensitive organic image sensor with diode-stacked pixels
(ダイオード積層構造を用いた高感度有機イメージセンサ)

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Organic image sensor is an emergent type of image sensor that utilizes organic materials in the light-sensitive layers or devices. The excellent absorption and sensitivity, low temperature and large area process compatibility, and their mechanism flexibility has made the organic image sensors promising for novel imaging applications, especially in medical and wearable imaging applications.

Among the organic image sensors, the ones with the pixel structure of diode stacks has been of great interest. This image sensor integrated the organic photodetectors and switching components in a single stack, which has a simple, vertically stacked, and two-terminal structure. The fabrication of this image sensor became simplified, which does not require additional electronic components in pixels. With this, high-resolution organic image sensors could be achieved.

However, the organic image sensors with diode-stacked pixel still leaves rooms for improvement. First, this image sensor required higher static power because individual pixel was not able to turn off at 0 V. Second, this image sensor showed a limited photo-responsivity due to the simplicity of the architecture with the fundamental limit of the organic photodiode.

In this dissertation, we aim to enhance the sensitivity of the organic image sensor with diode-stacked pixels. The outline of the dissertation is listed as below.

Chapter 1 Introduction

The topic of the dissertation, which is the organic image sensor with diode-stacked pixels, was introduced. Then the issue regarding this topic that will be discussed in this dissertation was mentioned.

Chapter 2 Organic image sensor

The fundamentals and background knowledge of organic image sensor was introduced. Firstly, the motivations of developing organic image sensor was mentioned. Then, organic photodetectors, the most essential components in the organic image sensor, were introduced. It is followed by the introduction of different types of organic image sensors to date. This chapter ends with the discussion of the applications of the organic image sensors.

Chapter 3 Materials and methods

The experimental materials and methods were introduced. This includes the materials, fabrication methods, and characterization methods utilized in the studies of the organic image sensor in this dissertation.

Chapter 4 Low-power organic image sensor based on diode-stacked pixels by turn-on voltage modification

The first work of this dissertation is summarized in this chapter. The organic image sensors with diode-stacked pixel still required higher static power because individual pixel was not able to turn off at 0 V. Here, we demonstrated low standby power organic image sensor based on two-terminal pixels. This vertically stacked pixel could be turned off at 0 V. This is enabled by the modification of the work function of the top electrode. This is caused by the modifications of the turn-on voltage of the organic blocking diode by changing the work function of the top electrode. With these, our organic image sensor exhibited improved imaging on/off ratio while achieving zero static turn-off power consumption.

Chapter 5 Highly responsive organic image sensor based on diode-stacked pixels with photomultiplication

The second work of this dissertation is summarized in this chapter. The organic image sensor with diode-stacked pixels still showed a limited photo-responsivity due to the simplicity of the architecture with the fundamental limit of the organic photodiode. Here, we achieved a simple diode-stacked organic image sensor with high responsivity. This is achieved with the integration with organic photomultiplication photodetector. The photodetector is optimized with an inverted structure, a 100:1 donor-acceptor ratio, and an optimized bottom contact to switch between a low dark current and high photocurrent response with photomultiplication. The photodetector is further stacked with a blocking diode to improve the on/off ratio to be integrated into an organic image sensor. Our photodetector pixel has a high responsivity more than 40 A/W, a low dark current

(2.53×10^{-4} mA cm⁻²), and a high on/off ratio (1.59×10^4 at 100 μ W cm⁻²). With this, the diode-stacked organic image sensor has a high current response with a low light imaging capability down to 1 μ W cm⁻².

Chapter 6 Summary and prospect

Finally, we concluded the dissertation. We have demonstrated both low-power and highly responsive organic image sensor with diode-stacked pixels in this dissertation. With these achievements, the future work and the prospect of the work were delivered.

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