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Polarization Analyzing Image Sensor with Monolithically Embedded Polarizer using 65nm CMOS Process

Sanshiro Shishido, Toshihiko Noda, Kiyotaka Sasagawa, Takashi Tokuda, Jun Ohta

Graduate School of Materials Science, Nara Institute of Science and Technology (NAIST),
8916-5 Takayama, Ikoma, Nara, 630-0192, Japan
Phone: +81-743-72-6051 E-mail: otha@ms.naist.jp

1. Introduction

The chirality of a molecule plays an important role in various chemical and biological reactions. The right-handed and left-handed forms of a molecule can be distinguished by their optical activity. The polarization angle rotates due to the optical activity of the chiral molecules when linearly polarized incident light propagates through a solution with chiral reactants. By detecting this polarization angle, chiral discriminations of optically active chemical solutions are realized. We propose a polarization analyzing sensor as a solution for analyses of optically active chemical compounds. In the previous work we have developed a polarization analyzing sensor based on the image sensor architecture to realize a real-time measurement of the incident polarization angle [1]. The fabrication process was 0.35μm CMOS (Complementary Metal Oxide Semiconductor) process. In this work, to realize the special resolution enhancement and a further miniaturization of the sensor size, we design a polarization analyzing image sensor using 65nm CMOS process for the first time.

2. Concept and design of the polarization analyzing image sensor using 65nm CMOS process

We fabricated a prototype polarization analyzing image sensor with embedded metal grid polarizers using 65nm CMOS process. The micrograph and the specification of the fabricated sensor are shown in Fig. 1 and Table I, respectively. Each polarization analyzing pixel was designed with a monolithically embedded polarizer with various angles, widths and pitches on the photodiode (Fig. 2). A high extinction ratio is also expected by a fine pitch metal wire grid polarizer in 65nm CMOS process which is smaller compared with visible wavelengths [2]. We also designed the chiral metal gratings for observing the effect of surface plasmon resonance on the optical activity of chiral metal gratings, inspired by Gonokami's work [3].

The pixel size is 20μm x 20 μm in the previous polarization analyzing image sensor. The pixel size is two types, 2.5 μm x 2.5 μm and 10 μm x 10 μm, as a prototype sensor.

The fabricated sensor chip has two readout pixel types, APS (Active Pixel Sensor) pixel and PWM (Pulse Width Modulation) pixel, to evaluate the image sensor operation in 65nm CMOS process. [4].

3. Characteristics of the polarization analyzing pixel TEG

We evaluated the characteristics of polarization analyzing pixel TEG (Test element group). The pixel TEG has APS pixels, and the pixel size is 10 μm x 10 μm. We measured the linearity of the grid less pixel output. The relationship between the illumination and the discharging rate of APS pixel is shown in Fig. 3. The sensor output is linear, and the gamma value is 0.9. We also measured the polarization characteristics of fabricated sensor chip (Fig.4, 5). Before measurements, the polyimide layer on the chip surface is removed by the laser machining. We successfully measured the polarization characteristics of two pixels which have different angle of polarizers, 0° and 90°, respectively. The extinction ratio is 1.7. Further characterization of polarization analyzing image sensor is currently undergoing.

4. Conclusions

We have proposed a polarization analyzing image sensor with a fine pitch polarizer using 65nm CMOS process for the first time. We successfully measured the polarization characteristics.

Acknowledgements

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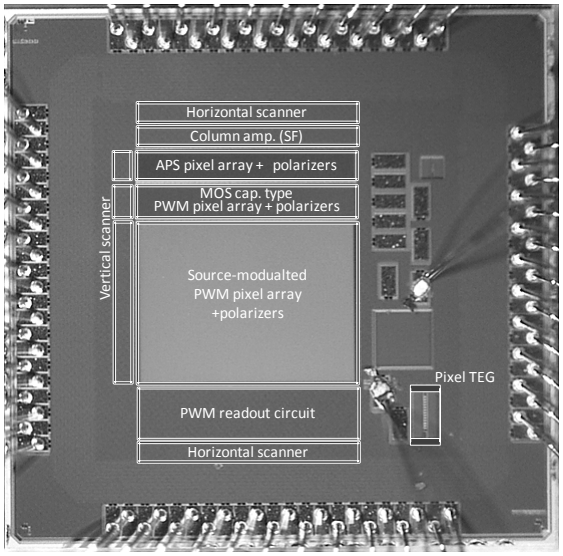

Fig. 1 Micrograph of the fabricated sensor.

Table I Specification of the fabricated sensor.

process	65-nm standard CMOS process
chip size	2.1 mm x 2.1mm
pixel size	• 2.5 μm x 2.5 μm (pixel array) • 10 μm x 10 μm (pixel TEG)
pixel count	• QVGA:348 x 248 (source modulated PWM) • 348 x 50 (MOS capacitor type PWM) • 348 x 50 (APS)
fill factor	32.4 % (pixel array) 49.0 % (pixel TEG)
optical black	upper 4rows, right & left each 4 columns
ADC resolution	10 bit (PWM)
readout	• APS (analog , serial) • PWM (digital, parallel)

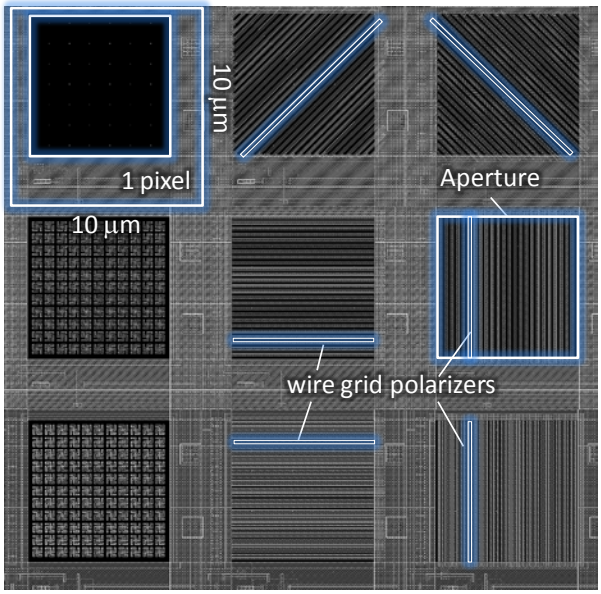

Fig. 2 Layout of the pixel array with wire grid polarizers.

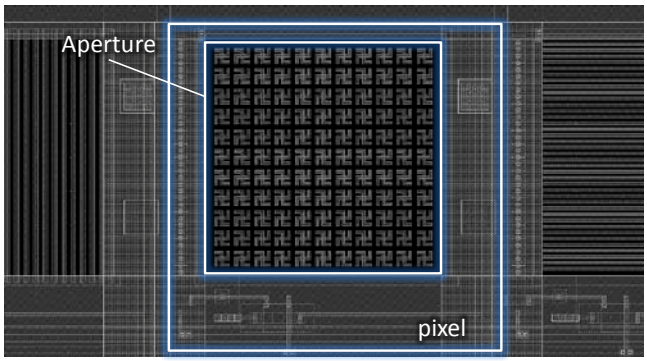

Fig. 3 Layout of chiral metal gratings.

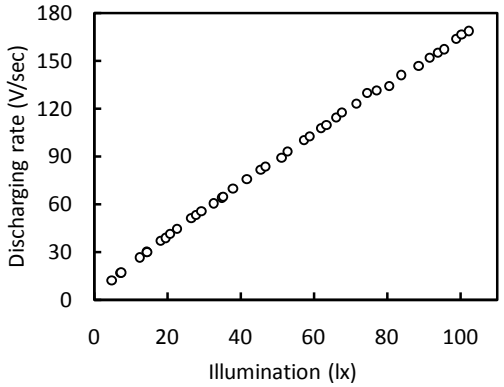

Fig. 4 Relationship between the illumination and the discharging rate of APS pixel.

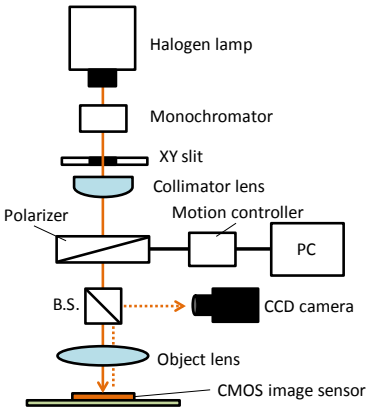

Fig. 5 Measurement setup for characterization of fabricated polarization analyzing image sensor.

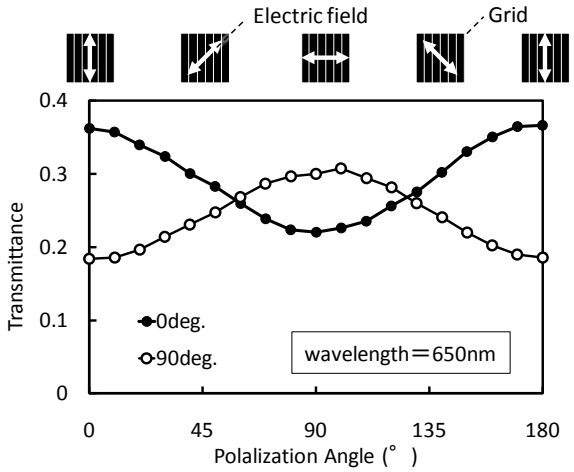

Fig. 6 Polarization characteristics of fabricated sensor chip. (wavelength = 650nm)

References

[1]T. Tokuda, H. Yamada, K. Sasagawa and J. Ohta, IEEE Trans. on Biomedical Circuits and Systems, **3** (2009) p.259.

[2]Z. Y. Yang and Y. F. Lu, Optics Express, **15** (2007) p.9510

[3]K. Konishi, T. Sugimoto, B. Bai, Y. Svirko, and M. Kuwata-Gonokami, Optics Express, **15** (2007) p.9575.

[4]S. Shishido, K. Kagawa, K. Sasagawa, T. Tokuda and J. Ohta, Jpn. J. Appl. Phys. **48** (2009) 04C193.