Averaging Pixel Current Calibration Algorithm for Reducing Fixed Pattern Noise in the Bolometer-Type Uncooled Infrared Image Sensor

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Abstract In this paper, we propose an averaging pixel current calibration algorithm for reducing fixed pattern noise (FPN) in the bolometer-type uncooled infrared image sensor. The averaging pixel current calibration algorithm is implemented by using active pixel, reference pixel, and calibration circuit. Active pixel and reference pixel have been integrated using on-chip polysilicon resistors. Resistance variation among active pixels due to process variation causes FPN. The principle of algorithm is that the dark current of reference pixel array is subtracted by the dark current of each active pixel. Thereafter, the subtracted current is converted into the voltage and the voltage is related to the pixel resistance value. Calibration circuit is used to adjust the calibration current. After calibration, nano-ampere current is output with small variation. The proposed averaging pixel current calibration algorithm is implemented by a chip which is composed of a 4 by 16 pixel array, calibration circuit, average current generators, and readout circuits. The chip was fabricated by using standard 0.35-μm CMOS process and its performance was evaluated.

Keywords: pixel current calibration algorithm, uncooled infrared image sensor, bolometer, fixed pattern noise

1. Introduction

Lately, research on bolometer-type uncooled infrared image sensor has been increasing for various fields such as military, medical, and non-destructive test. Uncooled infrared image sensor has many advantages in terms of low power consumption, high integration, and low cost. Among the various uncooled infrared image sensors, a bolometer sensor based on micromachining technology has a higher resistance temperature coefficient than other sensors. The response of a bolometer sensors, which is one type of thermal detectors is slow but does not depend on the wavelength of infrared light and can be used at room temperature. Therefore, there is no need for a thermoelectric cooler that consumes additional power and volume [1-4]

In order to array the pixel part, the resistance variation among the resistors integrated in the active and reference pixels causes serious fixed pattern noise. Various methods have been researched to solve the problem of the resistance variation among resistors integrated in the active pixel and reference pixel.

In this paper, in order to compensate the resistance variation occurring among the pixels of the bolometer-type uncooled infrared image sensor, the averaging pixel current calibration algorithm which compensates by averaging current generated by the respective reference pixel bolometers in the signal processing circuit was used. For verifying the proposed averaging pixel current calibration algorithm, the output nodes of each reference pixel are all tied up. The proposed averaging pixel current calibration algorithm is implemented by a chip which is composed of a 4 by 16 pixel array, calibration circuit, average current generators, and readout circuits. The chip was fabricated by using standard 0.35-μm CMOS process and was evaluated.

2. Operation principle

The circuit diagram of unit pixel is shown in Fig.1. It is composed of active pixel, reference pixel, and calibration circuit. Basically, the structure of entire pixels is PMOS-type current mirror structure. The bolometer resistor of active and reference pixel is integrated using poly-silicon resistor on chip. The bolometer resistor of reference pixel was designed to be blocked by metal layer. First, based on the Kirchhoff current law (KCL), the current generated by active pixel (I_{ACT}) is subtracted by the current generated by reference pixel (I_{REF}). The bolometer resistance of active pixel was designed smaller than that of the reference pixel. Therefore, the direction of the calibration current (I_{CAL}) is fixed to one side.

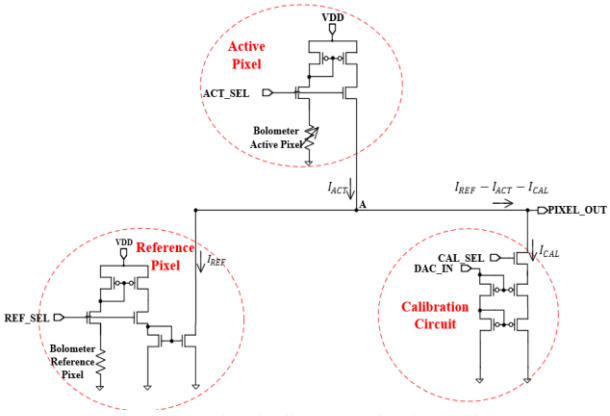

Fig. 1. Circuit diagram of unit pixel.

In order to detect the current change of active pixel, the reference pixel current (I_{REF})of entire array should be fixed. However, fixed pattern noise exists not only in bolometer active pixel but also in bolometer reference pixel.

It is important to remove the FPN of the reference pixel which determines the amount of current subtracted from each active pixel. Fig. 2 shows a block diagram of averaging pixel current calibration algorithm using reference pixel array. By sharing the output node of the reference pixel current, the average current ($\sum I_{REF}/N$) is obtained. When the number of reference pixel increases, the average current converges to average value. In this

way, when the active pixel current (I_{ACT}) is subtracted using the average current, FPN is removed.

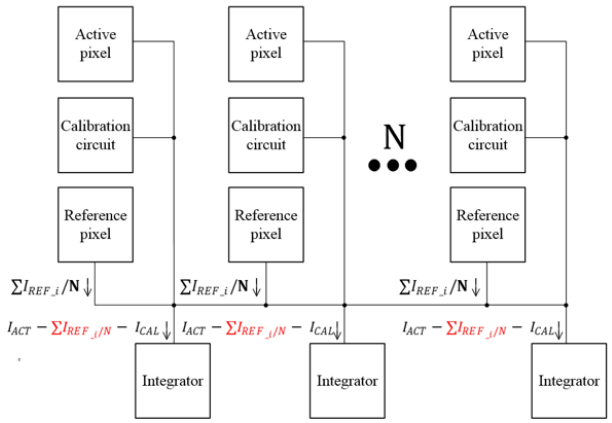

Fig. 2. Block diagram of the averaging pixel current.

Fig. 3 shows the layout of the designed readout circuit. It is designed using 0.35-μm standard CMOS process. The polysilicon resistor used as the bolometer resistor of reference pixel was designed with an 110kΩ resistance.

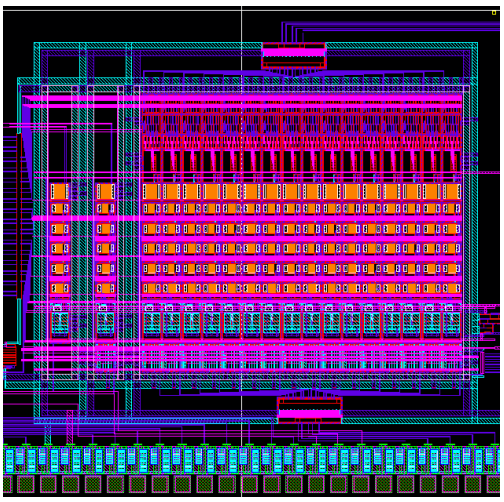

Fig. 3. Layout of the designed readout circuit.

Fig. 4 shows the distribution of the resistance value of the active pixel. Bolometer with resistance variation included in each active pixel was implemented with 90kΩ, 95kΩ, 100kΩ, 105kΩ and 110kΩ polysilicon resistor based on 100kΩ resistance, taking into account 10% resistivity variation.

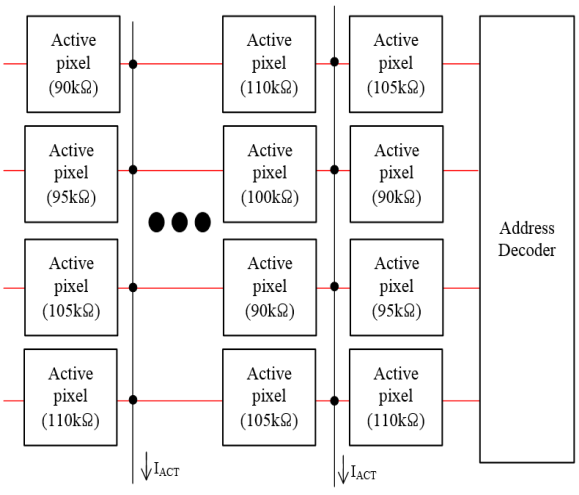

Fig. 4. Distribution of the resistance value of the active pixel.

3. Experimental results

Fig. 5 shows the experimental results before and after applying proposed calibration algorithm. Because of the $I_{REF} - I_{ACT}$ current value is μA order with the calibration algorithm off condition, the deviation of the output voltage of the integrator of the readout circuit according to the active pixel resistance is very large. Since the $I_{REF} - I_{ACT}$ current value is nA order with the calibration algorithm on condition, it can be confirmed that the output voltage of the integrator according to the active pixel resistance is uniform.

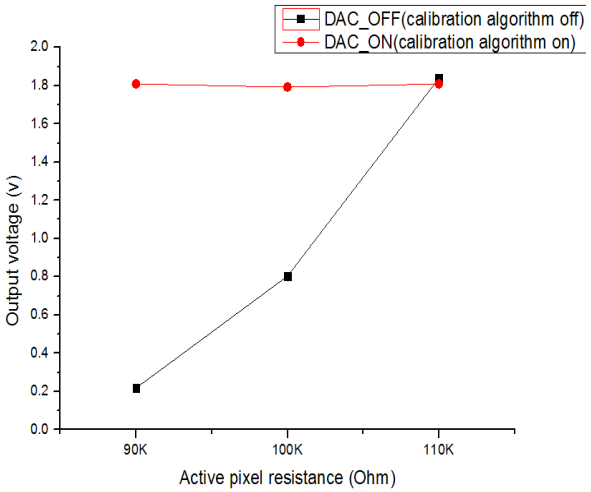

Fig. 5. Experimental results before and after applying proposed calibration algorithm.

4. Conclusion

We proposed an averaging pixel current calibration algorithm for reducing fixed pattern noise in the bolometer-type uncooled infrared image sensor. The chip was fabricated by using standard 0.35-μm CMOS process and its performance was evaluated. It is confirmed that the nearly identical output voltage can be obtained even if a resistance variation occurs among active pixels by applying the proposed averaging pixel current calibration algorithm.

Acknowledgements

This work supported by the Industrial Core Technology Development Program (Project No. 10052933) and Ministry of Trade, Industry & Energy (MOTIE) in Korea.

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