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A 3×3 pyroelectric detector array with improved sensor technology

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Abstract

A 3×3 pyroelectric array with P(VDF/TrFE) copolymer films on integrated CMOS circuits is described. The maximum specific detectivity of the sensors is in the order of 10^7 cm $\sqrt{\text{Hz}}$/W. An improved technology for the poling process is discussed. In order to achieve maximal sensitivity of a thermal IR sensor, an efficient absorption of the incident radiation is necessary. Results of the technology and the properties of thin nickel films as absorbers are presented.

1. Introduction

In recent years, the interest in the realization of pyroelectric sensor arrays on silicon integrated circuits has strongly grown. In an earlier paper a linear 8×1 array based on P(VDF/TrFE) copolymer films and a p-well CMOS process with aluminium gates was described [1].

A 3×3 pyroelectric detector array with improved sensor technology was developed. The 9 pixels of the array are formed by a patterned stack of a lower electrode, a spin-coated P(VDF/TrFE) copolymer film and an upper electrode/absorber; they are connected to integrated MOSFETs serving as impedance matching preamplifiers. The pixels and the MOSFETs are separated by an insulating layer that reduces the thermal and capacitive coupling. The pixels are addressed by two switching transistors, scanned by shift registers. In order to improve voltage responsivity and noise the extended gates of the MOSFETs are optimized.

A pyroelectric sensor element consists of a pyroelectric layer with aluminium electrodes on both surfaces. The bottom electrode is connected to the read-out circuit integrated into the silicon substrate. This requires the patterning of a stack of different materials. As a technological realization, a combination of wet- and dry-etching processes is used.

An important step in the device technology is the poling process. The device technology allows the on-chip poling of the copolymer layers. In the present investigation the conventional method of poling at room temperature was performed with evaporated metal electrodes [2]. The pyroelectric activity is mainly affected by the attainable poling field strength, which is limited by local breakdown. In this contribution, some possibilities to improve the poling behaviour are described.

In order to achieve maximal sensitivity of a thermal IR sensor, an efficient absorption of the incident radiation is required. For this reason it is necessary to replace the upper aluminium electrode by an electrode with a better absorption. Thin nickel films deposited by sputtering as absorber for IR radiation and upper electrode were used. Results of the technology and the properties of this absorber are presented.

2. Technology

The starting material of the CMOS process is n-type silicon. The p-well is formed by a two-step boron implantation followed by a drive-in step. The source and drain regions of the NMOS and PMOS transistors are obtained by two-step diffusions. Gate resistors with a value in the order of 10^{10} Ω are required in order to adjust the operating point of the MOSFETs. These devices are realized by p–n junctions operated at zero bias. The characteristics are tailored by deliberate radiation damage, i.e., helium implantation followed by annealing in nitrogen atmosphere. A detailed description of the CMOS process is given in ref. 3. A simplified cross section of a sensor element is shown in Fig. 1. The circuit diagram of a sensor pixel with an amplifying MOSFET and a read-out device is drawn in Fig. 2.

It has been demonstrated in an earlier paper, that the utilization of P(VDF/TrFE) copolymer layers with

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