The Characterization and Fabrication of Pyroelectric Infrared Sensor

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Abstract

The pyroelectric infrared (PIR) sensor with a calcium-modified lead titanate Pb_{1-x}Ca_xTiO_3 thin film with x = 0.3 [PCT(30)] thin film have been successfully fabricated. A RF planar magnetron sputter was used to deposit PCT(30) thin film. A perovskite thin film can be obtained. From the properties measurement we can obtain the remanent polarization \( P_r = 25.3 \ \mu \text{c/cm}^2 \) and coercive electric field \( E_c = 52.65 \ \text{KV/cm} \). The pyroelectric coefficient was measured as a function of temperature which was \( 4.13 \times 10^{-4} \ \text{C/m}^2 \text{K} \) at 300 degree C. For the PIR performance measurement, the voltage response of the single PIR sensor is \( 723.5 \ \text{VW} \) and the specific detectivity is \( 8.28 \times 10^6 \ \text{cmW}^{-1} \) at 0.3 Hz. In addition, a 2–D 8 \times 8 element PIR sensor array is finished with fabricated PIR sensors.

Key Words: Pb_{0.7}Ca_{0.3}TiO_3 (PCT(30)), Remanent Polarization, Coercive Electric Field, Pyroelectric Coefficient, Voltage Response, Specific Detectivity

1. Introduction

Infrared line and thermal radiation have been known for many years ago. The useful infrared radiation wavelength is about 0.8 \( \mu \text{m} \) – 30 \( \mu \text{m} \). Infrared sensor will detect the infrared radiation from the object. Since the infrared radiation is common radiation in many substances, IR sensor is one of the most useful sensors.

Infrared sensor can be classified into two major types that are thermal type and photon type. The photon type sensors often need to be cooled to obtain a better performance. In addition they are wavelength selective. On the other side, there are many advantages about thermal IR sensor such as no cooling equipment is needed, no radiation harmful, low cost, and easily integration.

In this experiment, a thermal type PCT(30) pyroelectric infrared sensor (PIR) is investigated. Furthermore, the fabricated PIR sensor is constructed an 8 \times 8 sensor array, too. In addition, for thermal insulation of the pyroelectric infrared (PIR) sensor and PIR 8 \times 8 array sensor, the V-groove etching technique provides thermal isolation and minimizes conductive heat losses between the detector element and the substrate. PIR sensors with V-grooves structure have low thermal mass and low thermal conductivity to the semiconductor substrate. In this experiment 5% TMAH solution at 85 \( ^\circ \text{C} \) etching condition is used to form V-groove structure [1].

2. Experimental Procedure

The PIR sensor thin films have been successfully fabricated with the PCT(30). The pyroelectric detector is fabricated on silicon chip. A Microelectromechanical Systems (MEMS) technique is also used to have the V-groove etching technique provides thermal isolation and minimize the conductive heat .The structure diagram is shown in Figure1. In addition, a RF planar magnetron sputter was used to deposit PCT(30) thin film and the RF-power is 5.73 W/cm² and the 2-inch target was made by ourselves. Then, the PCT(30) thin film