Fabrication and Characterization of Photon Radiation Detectors

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Akademisk avhandling som med tillstånd av Mittuniversitetet i Sundsvall framläggs till offentlig granskning för avläggande av licentiatexamen i elektronik ***måndagen den 17 december 2007***, klockan **13.15** i sal **O102**, Mittuniversitetet Sundsvall. Seminariet kommer att hållas på engelska

Abstract

In this thesis, fabrication and characterization of photon radiation detectors are studied. The focus has been to develop and improve the performance of optical measurement systems, but also to reduce their cost. The work is based on the study of two types of detectors, the position sensitive detector and the thermal detector.

Infrared detectors are usually subcategorized into photonic detectors and thermal detectors. In the thermal detectors, heat generated from the incident infrared radiation is converted to an electrical output by some sensitive element. The basic structure of these detectors consists of a temperature sensitive element connected to a heat sink through a thermally isolating structure. Thin membranes of Silicon and Silicon nitride has commonly been used as thermally insulation between the heat sink and the sensitive elements. However, these materials suffer from relatively high thermal conductivity, which lowers the response of the detector. The fabrication of these membranes also requires rather advanced processing techniques and equipment. SU-8 is an epoxy based photoresist, which has low thermal conductivity and requires only standard photolithography. A new application of SU-8 as a self-supported membrane in a thermal detector is presented. This application is demonstrated by the fabrication and characterization of both an infrared sensitive thermopile and a bolometer detector. The bolometer consists of nickel resistances connected in a Wheatstone bridge configuration, where as the thermopile uses serially interconnected Ti/Ni thermocouple junctions.

The position sensitive detectors include the lateral effect photodiodes and the quadrant detectors. Typical applications for these detectors are distance measurements and as centering devices. In the quadrant detectors, the active region consists of four pn-junctions separated by a narrow gap. The size of the active region in these detectors depends of the size of the light spot. In outdoor application, this spot size dependence degrades the performance of the four-quadrant detectors. In this thesis, a modified four-quadrant detector having the pn-junctions separated a larger distance has been fabricated and characterized. By separating the pn-junctions the horizontal electric filed in the active region is removed, making the detector spot size insensitive.

Linearity of the lateral effect photodiodes depends on the uniformity of the resistive layer in the active region. The introduction of mechanical stress in a LPSD results in a resistance change mainly due to resistivity changes, and this affects the linearity of the detector. Measurements and simulations, where mechanical stress is applied to LPSDs are presented, and support this conclusion.