A NOVEL Ge MOS DETECTOR FOR 1.3 μm AND 1.5 μm LIGHT WAVE COMMUNICATION

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INTRODUCTION

Silicon-based optical receivers operating over the important fiber optic communications wavelengths of 1.3 and 1.5 μm have attracted much research effort recently. A number of Silicon-based material systems are being investigated [1] and the optical absorption properties of Ge and SiGe make them excellent materials for the fabrication of optoelectronic devices. In this work, we report the results of a MOS detector fabricated on Ge substrate and operated in 1.3-1.5 μm wavelength.

NOVEL Ge MOS DETECTOR FABRICATION

The gate oxide of the MOS diode was grown by liquid phase deposition (LPD) on 0.4Ω-cm n-type Ge wafer. The growth of LPD oxide is conducted in a supersaturated hydrofluosilicic acid (H_2SiF_6) solution at 50℃. The oxide thickness was measured by ellipsometer. The MOS diodes had Al gate electrodes with various circular areas defined by photolithography. The device structure is shown in the inset of Fig. 2.

RESULTS AND DISCUSSION

A simplified mechanism of LPD growth was originally proposed by Nagayama et al. [2] based on the reaction of H_2SiF_6 with water to form hydrofluoric acid and solid SiO_2.

$$H_2SiF_6 + 2H_2O \Leftrightarrow SiO_2 + 6HF \qquad (1)$$

This model shows the increased supersaturation and hence the increased deposition of SiO_2 by the addition of water to the growth solution.

The LPD oxide thickness vs growth time on both Si and Ge substrates is illustrated in Fig.1. We can see that the growth rate of LPD oxide on Si substrate is much higher than that on Ge substrate, especially in the first 2 hours. After 2 hrs, the growth rate of LPD oxide on Ge substrate starts increasing. Fig. 2 shows the current voltage (I-V) curves of Al/LPD oxide/n-Ge detectors with different oxide thickness. Under negative gate bias, the step-wised I-V characteristics indicate the two current transport mechanisms of electron and hole tunneling [3]. Note that as the oxide getting thicker, the inversion current becomes larger. It may be because that the thick oxide generates large stress at Ge/SiO_2 interface, and creates interface states. The large interface states increases the thermal generation rate of holes in the deep depletion region of PMOS, and therefore, the dark current increases with the increase of oxide thickness.

Fig. 3 shows the I-V characteristic of the PMOS detector exposures to 1.3 μm light wave with different light intensity. The maximum external quantum efficiency is estimated approximately 60%. This Ge detector can be easily integrated into silicon substrate by grown a Ge epi-layer on silicon substrate.

SUMMARY

We have demonstrated a novel Ge photodetector using the MOS tunneling structures. The oxide is directly grown on Ge substrate by liquid phase deposition. Under negative gate bias, the dark current is limited by the thermal generation process. This novel photodetector can operate with 1.3 and 1.5 μm light wave and can be applied to the fiber optic communications

REFERENCES

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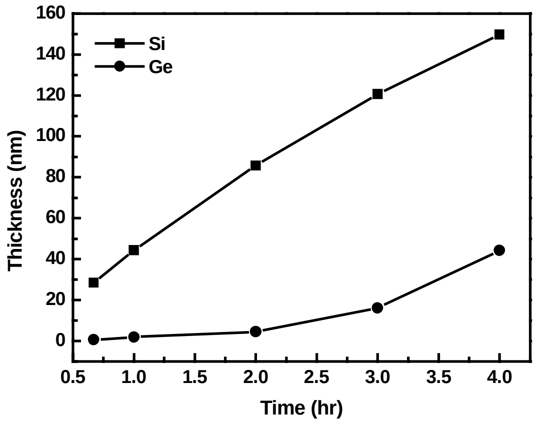

Fig.1 LPD oxide thickness vs growth time on both Si and Ge substrates.

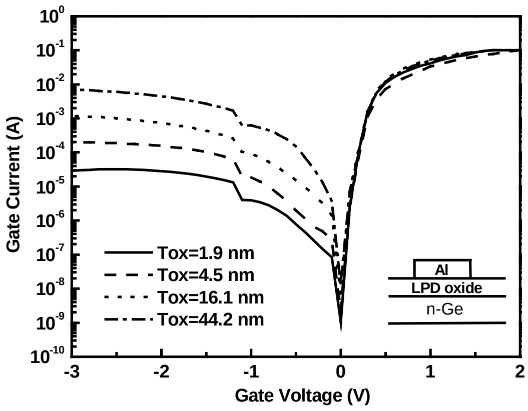

Fig. 2 The I-V curves of PMOS Ge detectors with different oxide thickness prepared by liquid phase deposition. The device structure is shown in the inset.

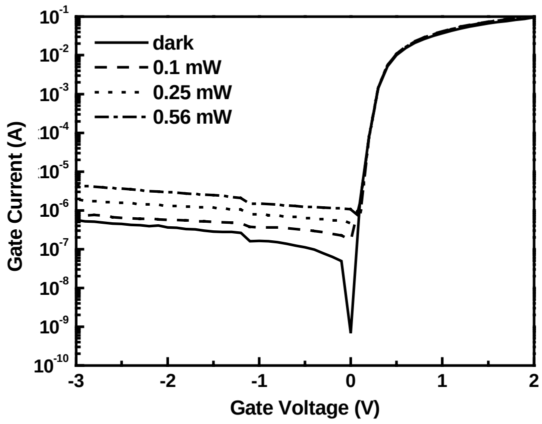

Fig. 3 The I-V curves of PMOS Ge detector exposures to 1.3 μm light wave with different light intensity. The oxide thickness is 1.9 nm.