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Dark Current Suppression for Ni/Ge Schottky Junction by Plasma Post-Oxidation Passivation

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Introduction

Metal-semiconductor-metal photodetectors (MSM -PDs) have been attracting a lot of research interests for their advantages such as easy fabrication, ultrafast response and large bandwidth. However, the large dark current, especially for Ge-based MSM-PDs, greatly degrades the device performance. The surface leakage such as trap-assisted tunneling current is a large component of the dark current of MSM-PDs, which is expected to be suppressed by proper surface passivation of Ge [1]. In this paper, the effect of plasma post-oxidation (PPO) passivation [2] on the reduction of dark current in Ni/Ge Schottky junction is examined. It is found that the surface leakage current of Ni/Ge Schottky junction is sufficiently decreased by the PPO passivation, which is attributed to the reduction of leakage paths due to interface defects.

Experiments

The fabrication process and device structure are shown in Fig. 1. After the pre-cleaning of Ge, the PPO passivation was performed for 1-nm-thick Al_2O_3/Ge structures fabricated by ALD. Subsequent to a 2nd-ALD of 19 nm Al_2O_3, Ni was sputtered and patterned to form the Schottky junctions on the etched window of Al_2O_3/GeO_x passivation layer. Finally, the Al was deposited as back contact.

Results and discussion

Figure 2 shows the I-V characteristics of Schottky junction w/ and w/o PPO passivation. The leakage current through the Schottky junction is separated into surface leakage (J_S) and bulk leakage (J_B) using the assumption: $I_{Dark\ Current} = J_S \times L_{Circumference} + J_B \times S_{Area}$. A significant suppression of surface leakage in the Ni/Ge Schottky junctions is observed, as shown in Fig. 3. We found that J_S is reduced from 4.41 μA/cm to 0.13 μA/cm after PPO passivation. This reduction is attributable to low interface defects of Al_2O_3/GeO_x/Ge structure taken from MOS capacitors which is less than 3×10^{11} $cm^{-2}eV^{-1}$ (data not shown). A flat band voltage of -1.13 V is obtained with the PPO passivation, suggesting the Ge surface surrounding the Ni metal is weakly accumulated when a difference between Ni and Ge work function is assumed to be -0.925 eV. This result is consistent with the Schottky barrier height (SBH) of 0.53 V obtained from the Richardson plots of temperature dependence of the reverse current at -1 V (data not shown). A low minority carrier concentration near the Ge surface due to the modulation of flat band voltage of Al_2O_3/GeO_x/Ge structure is also a possible reason for the dark current suppression for Ni/Ge Schottky junction.

Acknowledgement

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References

[1] M. Takenaka et al., Optics Express, Vol. 20, Issue 8 (2012) [2] R. Zhang et al., Appl. Phys. Lett. 98, 112902 (2011)

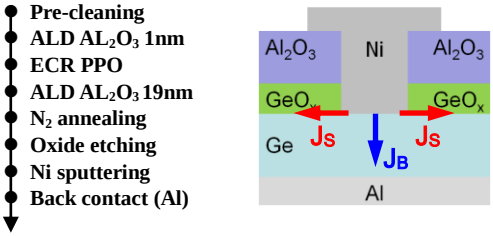

Fig. 1 Process flow and schematic cross section of Schottky junction.

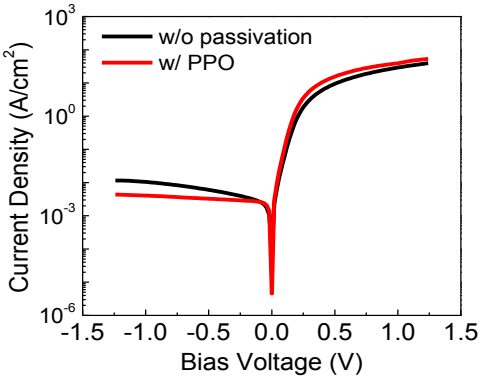

Fig. 2 I-V characteristics of Schottky junctions w/ and w/o PPO passivation.

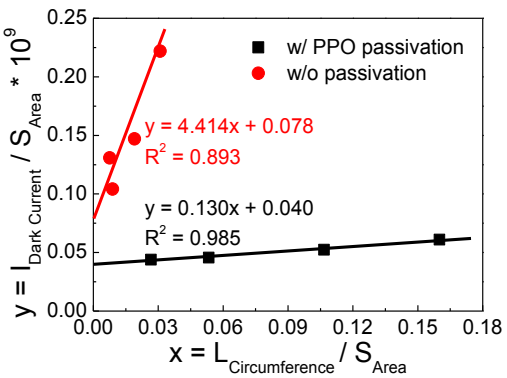

Fig. 3 The linear fitting for separation of the surface leakage (slope of line) and bulk leakage (intercept of line).