Extended Abstracts of the 2018 International Conference on Solid State Devices and Materials, Tokyo, 2018, pp937-938

Mapping of Ni/SiN_x/n-SiC Structure Using Scanning Internal Photoemission Microscopy

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Abstract

SiN_x films formed on n-SiC layers have been characterized by using scanning internal photoemission microscopy (SIPM) in metal-insulator-semiconductor (MIS) diode structure. After applying forward-biased voltage stress up to 30 V, the diode was partially degraded. SIPM clearly imaged the degradation pattern with a large photocurrent, which consisted with the microscopy image. These results clarified that the partial degradation induced a leak path with a low energy barrier.

1. Introduction

Recently, the development of high-performance insulating films deposited at low temperatures has been desired in various application fields such as 2.5/3-dimensional LSIs, solar cells, organic electroluminescence displays, and so on [1]. Taking into account the traditional insulating material of SiN_x, we have examined the formation of insulating films of high density at low temperatures by plasma-enhanced chemical vapor deposition and reactive sputtering [2-4].

On the other hand, we have developed SIPM that can map the electrical characteristics of Si, GaAs, SiC and GaN Schottky contacts [5]. In this paper, we applied SIPM to characterize degradation of low-temperature-deposited SiN_x films under voltage application in SiC MIS structure.

2. Sample preparation

A 9.73-µm-thick n-SiC (n: 1.2×10^{16} cm^{-3}) layer was grown on a 4H-n-SiC substrate as shown in Fig. 1. Then, 50- or 20-nm-thick SiN_x layers were deposited by RF reactive sputtering using pure Si target and Ar + N2 gas mixture. Circular 100-nm-thick Ni contacts (200 µm in diameter) were deposited on the SiNx surface by the electron beam evaporation. After that, InGa ohmic contacts were deposited on the back surface.

SIPM is based on the internal photoemission (Photoresponse) measurement. When a monochromatic light with a photon energy ($h\nu$) is incident on the Ni/SiN_x/SiC structure, we measure a photocurrent as shown in Fig. 2. Where photoyield (Y) is defined as photocurrent per number of incident photons. In the SIPM measurements, one focuses and scans the beam over the interface to obtain 2-dimensional imaging of Y with a green laser (λ = 517 nm). The diameter of the laser beam was less than 2 µm.

3. Results and Discussion

We applied forward-biased voltage stress up to 30 V as shown in Fig. 2. For the samples with the 20- and 50-nm-thick SiN_x layers, the current increased sharply at around 13 and 20 V, respectively. These are symptoms of the degradation. Before applying the voltage stress, the surface of the dot was flat in the Nomarski microscope image as shown in Fig. 3(a). After the stress, however we found a variation in surface morphology, where the surfaces consist of rough and flat regions as shown in Fig. 4(a). Because no degradation occurred at the edge of the dot, the SiN_x films have a variation in the breakdown field within the dot.

We also conducted SIPM measurements for both samples. After the stress, Y increased by 2-3 times in the rough regions (Fig. 4(b)). The Y image is consistent with the microscope image. These results indicate that the SiNx film was partially degraded and a leak path with a low energy barrier was formed. Therefore, we confirmed that SIPM is also available for degradation of MIS structure.

4. Conclusions

SIPM measurements were applied to map Ni/SiN_x/SiC MIS structure. After application of the voltage stress of 30 V, partial degradations were clearly visualized in the SIPM Y maps. We found that this method is a powerful tool to investigate symptoms of the degradation of the MIS structure.

Acknowledgements

A part of this work was supported by a Grant-in-Aid for Scientific Research C 18K04228 and 15K05975of the Ministry of Education, Culture, Sports, Science and Technology.

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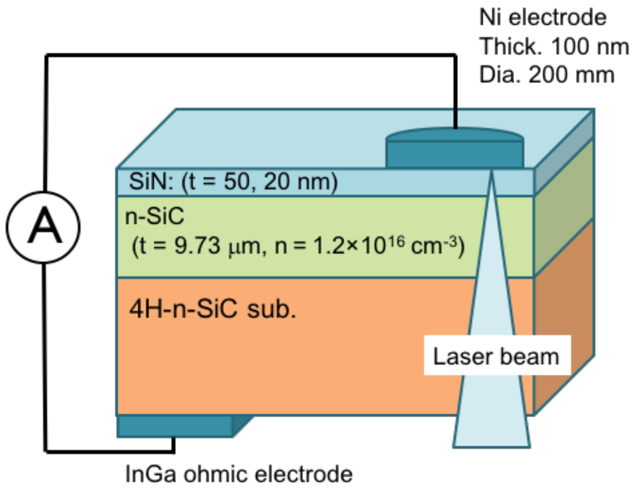

Fig. 1 Device structure of Ni/SiN$_x$/n-SiC MIS structure.

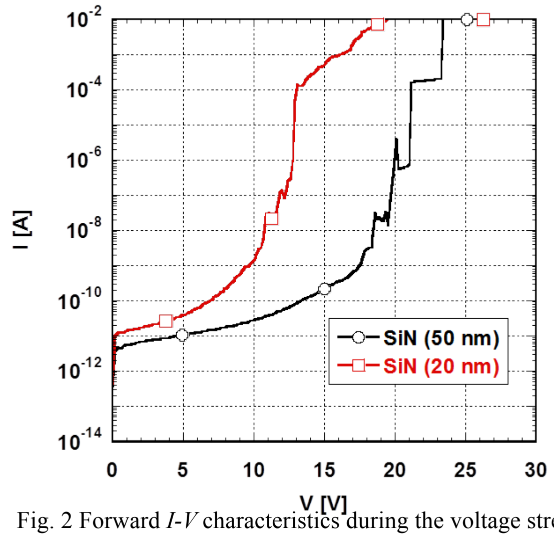

Fig. 2 Forward *I-V* characteristics during the voltage stress.

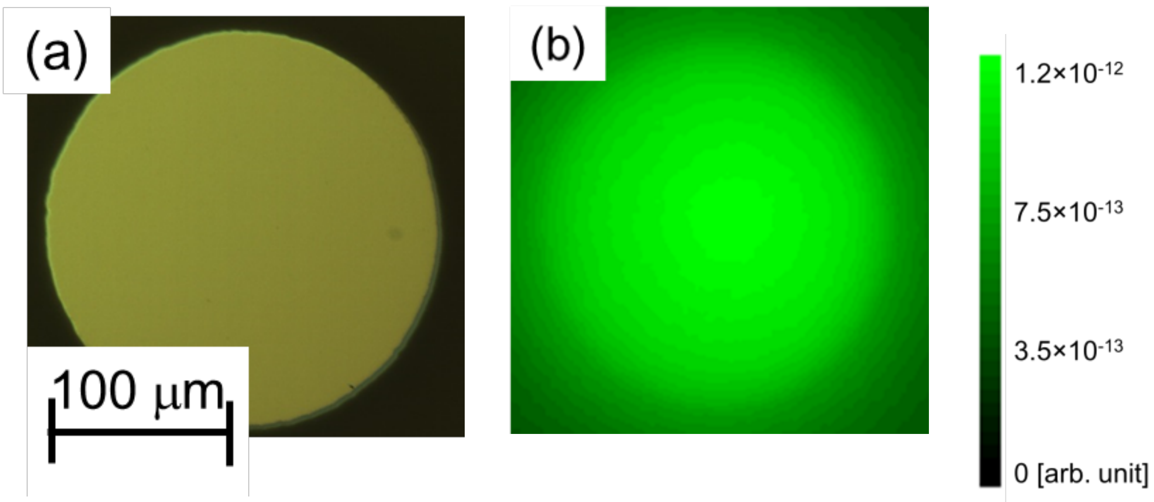

Fig. 3 (a) Nomarski microscope image and (b) photocurrent map of the Ni electrode on SiN$_x$ (t = 50 nm) in the as-deposited condition.

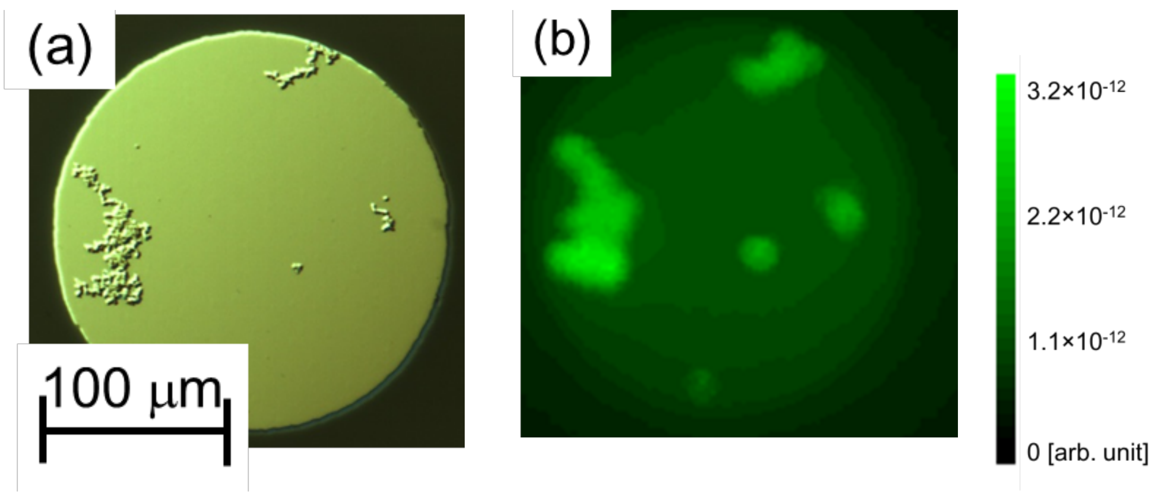

Fig. 4 (a) Nomarski microscope image and (b) photocurrent map of the Ni electrode on SiN$_x$ (t = 50 nm) after applying the voltage stress up to 30 V.