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# Complementary analysis for dislocations of GaN compound semiconductors using STEM and APT

Norihito Mayama,[1,*] Kei Watanabe,[1] Kazuya Toda,[1] Jun Koyama,[1] Satoshi Ishimura,[1] Mina Suganuma,[1] Masakazu Sugiyama,[2]

[1]*Toshiba Nanoanalysis Corporation, 8 Shinsugita-cho, Isogo-ku, Yokohama 235-8522 Japan.*
[2]*Research Center for Advanced Science and Technology, The University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo 153-8904 Japan.*

*corresponding author's e-mail: norihito.mayama@nanoanalysis.co.jp

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For GaN compound semiconductors, the position of dislocations was confirmed by STEM, and the elemental distribution was clarified by APT. From the results of APT, cluster segregation of Mg and In was observed on the dislocation, and it could be considered that they were diffused along the dislocations.

## 1. Introduction

In the development of semiconductor devices, control of the structure, interface steepness, crystal defects, distribution and concentration of dopant elements, etc. are important for evaluation of device characteristics and reliability. Analysis of crystal defects is mainly performed by transmission electron microscopy (TEM) and scanning TEM (STEM), and it is possible to identify the type of dislocations. However, it is difficult to observe element segregation to dislocations by STEM/EDS (energy dispersive spectroscopy) analysis. On the other hand, atom probe tomography (APT) is an effective analysis for local three-dimensional element distribution.

In this study, for GaN compound semiconductors with nm-level island structure [1], the position of dislocations is confirmed by STEM, and the elemental distribution is clarified by APT, in order to understand the element segregation to dislocations.

## 2. Experimental

The needle specimen was fabricated by focused ion beam (FIB) milling. Before the fabrication, the position of dislocations was confirmed by STEM. APT analyses were performed using LEAP3000XSi(AMETEK) in a laser pulse mode. The pulse energy was about 0.01 nJ with a pulse repetition of 500 kHz. The analyses were performed at 30 K with a detection rate of 0.002 atom/pulse.

## 3. Results and Discussion

Fig. 1 shows the STEM image of needle specimen before APT analysis and the results after the analysis. The threading dislocation from pGaN to nGaN was observed near the center of needle specimen from STEM image. From the results of APT, linear element segregation along the dislocation was not observed, but cluster segregation of Mg and In was observed on the dislocation in AlGaN layer. In addition, it was found that a pit was formed on the dislocation in the island structure layer. Mg was segregated as a cluster at the origin of the pit. From the above results, it can be considered that the diffusion of Mg and In occurs along dislocations.

## 4. Summary

In this study, it was found that the combination of APT analysis and STEM observation could evaluate element segregation to dislocations. It can be considered that the diffusion of Mg and In occurs along dislocations.

## 5. References

[1] T. Arakawa et al., IC-MOVPE XVIII, 2C-1.4, pp.34-35 (2016).

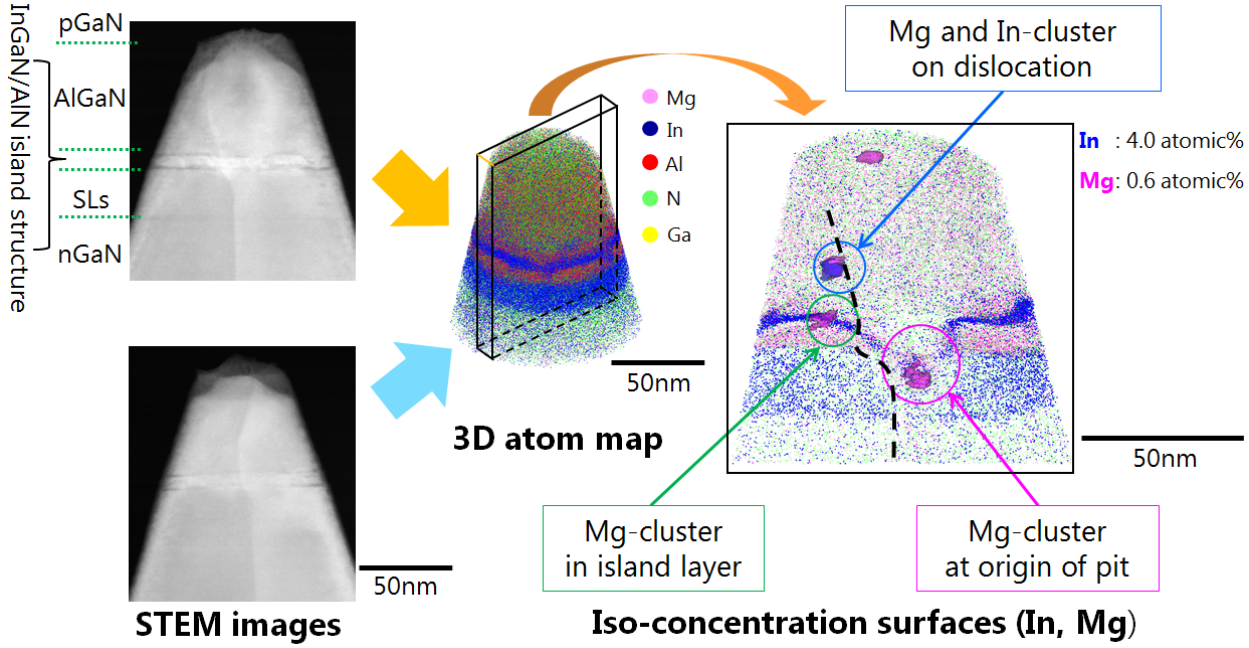


**Fig. 1** (a) STEM images of needle specimen, (b) 3D atom map and (c) iso-concentration surfaces (In, Mg).