Dislocation reduction in InN film grown with in situ surface reformation by radical beam irradiation

**立命館大理工 [1]　°(D) Faizulsalihin bin Abas[1]，(M1) 藤田　諒一 [1]，
毛利　真一郎 [1]，荒木　努 [1]，名西　憓之 [1]**

**Ritsumeikan Univ. [1], °Faizulsalihin bin Abas[1], Ryoichi Fujita[1],
Shinichiro Mouri[1], Tsutomu Araki[1], Yasushi Nanishi[1]**

E-mail: re0034sf@ed.ritsumei.ac.jp

Introduction

The advantages of InN such as the smallest effective mass, the largest mobility, the highest peak velocity, and the smallest direct-band gap energy among III-nitride semiconductors make it a very promising material in various applications including high-speed electronic and long-wavelength optoelectronic devices. However, one of the biggest challenges in developing InN is the presence of high density of threading dislocation due to large lattice mismatch between InN and the growth substrates. It is well known that threading dislocation usually contribute to high residual carrier concentration and cause deterioration of mobility and device performance. Therefore, a substantial study on the reduction of threading dislocation density is essential to improve InN crystalline quality in order to utilize the full potential of InN. In this study, in situ surface reformation method by radical beam irradiation was investigated to reduce threading dislocation density in InN.

Experiments and Results

InN films used in this study were grown on MOCVD-grown (0001) GaN/sapphire substrate using radio-frequency plasma-excited molecular beam epitaxy (RF-MBE). After the substrate was thermally cleaned at 750 °C for 10 min and a thin GaN layer was deposited at 650 °C for 3 min, InN template was grown at 435 °C for 60 min. The template was then irradiated with N radical beam at 435 °C with a plasma power of 200 W for 60 min. Afterwards, InN film was regrown on the irradiated template at 435 °C for 60 min. TEM specimen for cross-sectional observation was prepared by focused ion beam etching and observed with a JEOL2010 electron microscope operated at 200 kV.

Fig. 1 shows a cross-sectional TEM image of InN film grown with in situ surface reformation by radical beam irradiation method with **g** = 1-100. As can be seen, the edge dislocations in InN grown on the irradiated InN template bent and merged at several places along the regrowth interface. Furthermore, the threading dislocation density reduces by an order of magnitude from about 2×10^{10} cm^{-2} to 6×10^{9} cm^{-2} in some regrown regions. Possibly, this could be attributed to the surface reformation of InN template by N radical beam irradiation. The results obtained from this study have laid an important platform from which to reduce threading dislocation density in InN film. Further work should be carried out to understand the driving force of dislocation bending and to achieve further reduction of dislocation density.

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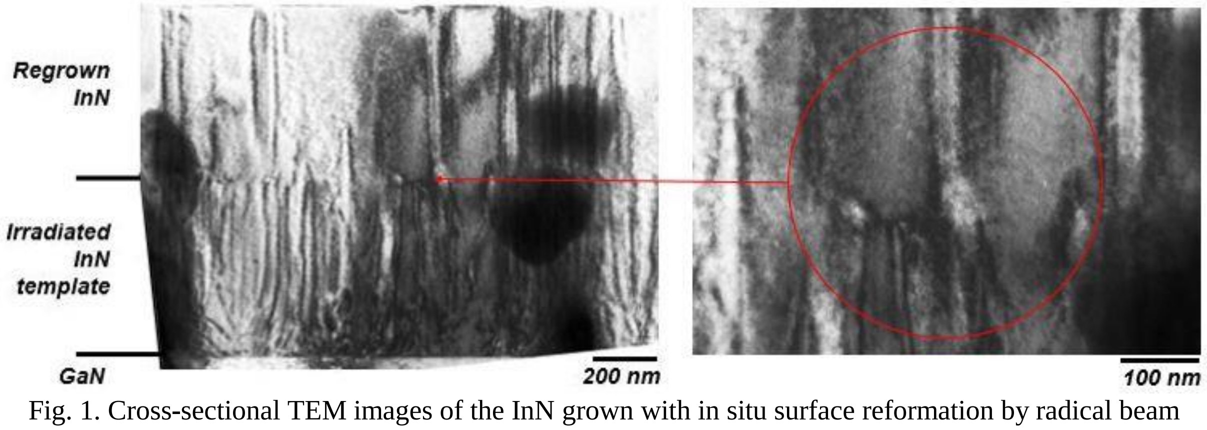

Fig. 1. Cross-sectional TEM images of the InN grown with in situ surface reformation by radical beam irradiation method with **g** = 1-100.