

# Surface nitridation of GaAs(001)-(n×6) by reactive atomic nitrogen radical

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## ABSTRACT

The surface nitridizing process on As-rich GaAs(001)-(n×6) surface performed by reactive atomic nitrogen radical was investigated by using *in-situ* x-ray photoelectron spectroscopy (XPS) and scanning tunneling microscopy (STM). STM images show that the initial nitridation process is prefer to occur in the trough regions of As dimer rows with N atoms chemically bonded to second-layer Ga atoms. With the increase of nitrogen radical exposures, the periodic As-As dimer rows were broken down, some As atoms were replaced by N atoms. It was found that nitridation reaction is significantly influenced by nitridation parameters (reactive temperature and nitrogen exposure). The nitridation productivity was sharply increased at a higher substrate temperature. After elevating the reaction temperature to 580°C, 3-D GaN islands would formed on surface.

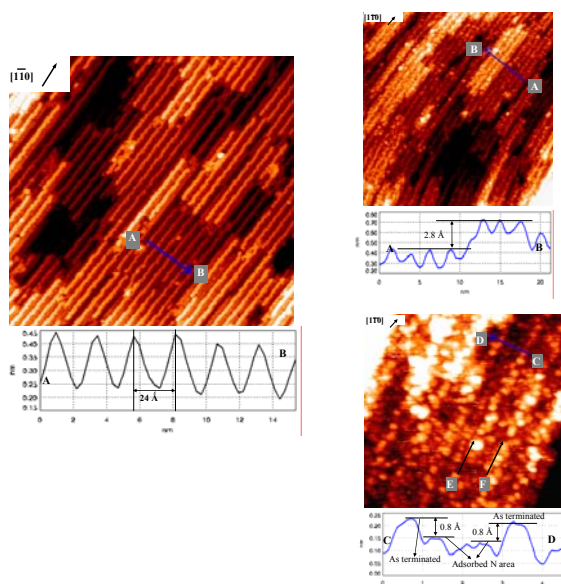
## Object:

The initial nitridation of GaAs substrates plays a decisive role in easing the lattice strain between GaN and GaAs, and help to improve the quality of the single-phase GaN epitaxial film. By using STM, to explore the nitridation process in atomic scale.

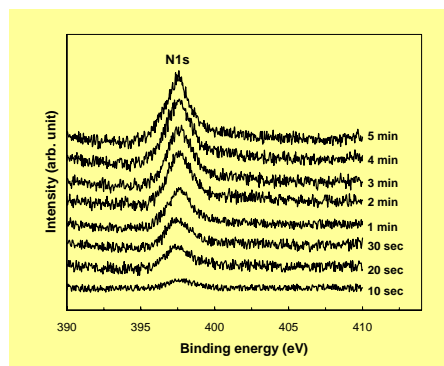
## Method:

The Atomic nitrogen flux was generated by the HD25 atom source using 350 W of RF power, and the N<sub>2</sub> partial pressure was at  $5.0 \times 10^{-5}$  mbar. Before deposition, GaAs(001) surface was prepared by cycles of Ar<sup>+</sup> ion sputtering and annealing to 550°C. The clean (n×6) GaAs reconstruction surface was firstly obtained by STM. *In-situ* XPS spectra and STM images were obtained after each nitridized stage by transferring the sample from growth to analysis chamber *via* the gate valve.

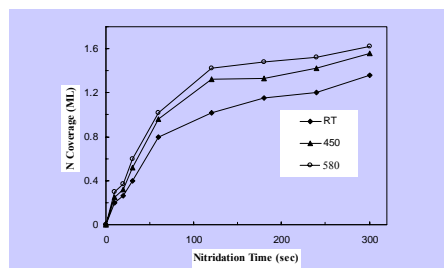
## Results and Discussion



**Fig. 1.** The filled-state STM images of As-rich GaAs(001) surface after nitridation by reactive atomic nitrogen radical at RT. (a) clean GaAs(001)-(n×6) surface (800×800 Å<sup>2</sup>); (b) 10 seconds treatment (800×800 Å<sup>2</sup>), (c) close-up of (b), with scan size of (200×200 Å<sup>2</sup>).



**Fig. 2.** N 1s peaks of nitridized GaAs(001) surface at 580 °C for different nitridation times after XPS background subtracted.



**Fig. 3.** Nitrogen coverage of nitridized GaAs(001) as a function of nitridation temperatures (Room temperature (RT), 450 °C, 580°C) and nitridation time.

## Conclusion:

The surface initial nitridizing process on As-rich GaAs(001)-(n×6) has been studied by using *In-situ* XPS and STM. It was found that the initial nitridation occurs easily at the trough of As dimer rows, where N atoms chemically bond to the second layer Ga atoms to compound the preliminary nitrides. Furthermore, the formed surface nitrides will limit the diffusion of in-coming N atoms and outgoing As atoms, which reduce the nitride productivity in the afterward nitridized reaction. After filled in the trough regions, in the second stage reaction, the planting N atoms open the surface As-As dimers, then partially replace As atoms on the top layer, which results in the As-As dimer rows being dissolved.