[III~21]

Transition Metal Nitride Formed by Simultaneous Physisorption and Thermal-evaporation; TiN/Si(100)

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I. Introduction

Recently the usage of nitride has been expanded to various industrial novel applications such as GaN for emitting blue light in the display, SiN for the cantilever of atomic force microscope, and TiN for a diffusion barrier at the metal/semiconductor interface. The major advantages of nitrides in such applications are in their structural stability as well as chemical inertness. In the present study, a novel technique has been employed to produce TiN on Si(100) held at 40K under ultrahigh vacuum (UHV). Since the single N species, NH_3, can be adsorbed as multi-layers on 40K Si(100), the amount of NH_3 can be controlled by exposure. During NH_3 exposure the other element, Ti, is thermally evaporated and controlled by a thickness monitor. The simultaneous NH_3 exposure and Ti evaporation to Si(100) enabled for both species to be well-mixed on the cold Si(100), and TiN as well as its precursors $TiNH_x$ could be formed even without any thermal treatment.

II. Experimental

In order to prepare atomically clean B-doped Si(100) with ρ = 0.2 - 0.4 $\Omega \cdot$cm, the protecting oxide layer was initially formed by, so called, Shiraki etching method. The protecting oxide layer was removed under UHV by resistive heating, while other parts of the sample holder were kept at 40K. After checking clean 2 x 1 pattern by LEED and contamination-free surface by XPS, the surface was cooled to 40 K through the back-side thermal contact with OFHC copper bolt connected to the cold-head using the screw driver installed inside the chamber. As soon as the temperature reached 40 K, 10 L of NH_3 was first exposed to this cold surface using a variable leak valve for forming an overlayer protecting the surface from being disrupted by the evaporated metal. Then the metal was evaporated, while NH_3 was continuously exposed. The density of states of Ti 2p, N 1s, O 1s, Si 2p, and the survey were obtained to identify the chemical reaction between the adsorbed species. The thermal stability and