RF-Plasma MBE Growth of Epitaxial Metallic TaN_x Transition Metal Nitride Films on SiC

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Integration of epitaxial metal layers within semiconductor devices will enable substantial performance benefits, design flexibility, and novel device structures such as metal-base transistors [1] and integrated epitaxial superconductor/semiconductor heterostructures [2]. We have previously reported on the use of RF-plasma MBE to epitaxially grow metallic niobium nitride (NbN_x) thin films and III-N/NbN_x heterostructures on hexagonal SiC substrates [3-5]. More recently, we have reported on novel device lift-off processing enabled by the selective etching of NbN_x under III-N HEMTs [6]. In this presentation, we will discuss our recent work on the epitaxy of a similar transition metal nitride (TMN) material: TaN_x. As with NbN_x, the equilibrium phase diagram for TaN_x is complex, so demonstrating control of the TaN_x phase is important for practical applications. We have successfully grown single-phase thin films of single-crystal TaN_x on 3"-diameter SiC substrates using a customized Scienta-Omicron PRO-75 MBE system equipped with a six-pocket electron-beam evaporator to generate the Ta flux. We will discuss the MBE growth conditions for TaN_x and demonstrate the epitaxy of AlN/TaN_x heterostructures on SiC. The films were characterized *in-situ* using RHEED, and *ex-situ* using optical and atomic-force microscopy, contactless sheet resistance, x-ray diffraction, and transmission electron diffraction.

This work was funded by the Office of Naval Research.

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Supplementary Page:

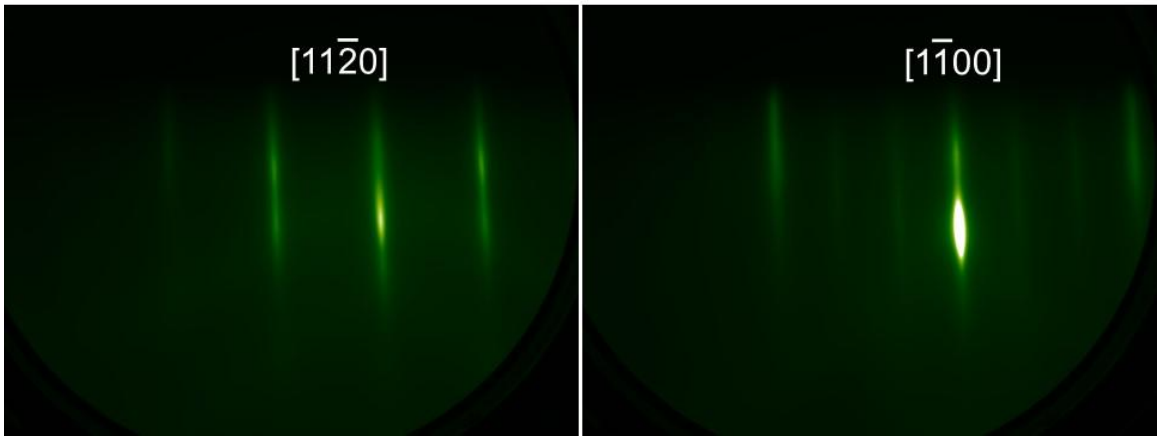

Figure 1. RHEED patterns showing a (1x3) surface reconstruction of a 50 nm thick TaN_x epitaxial film on 6H-SiC during a growth interrupt. The diffraction pattern indicates a single-crystal epitaxial film with low surface roughness.

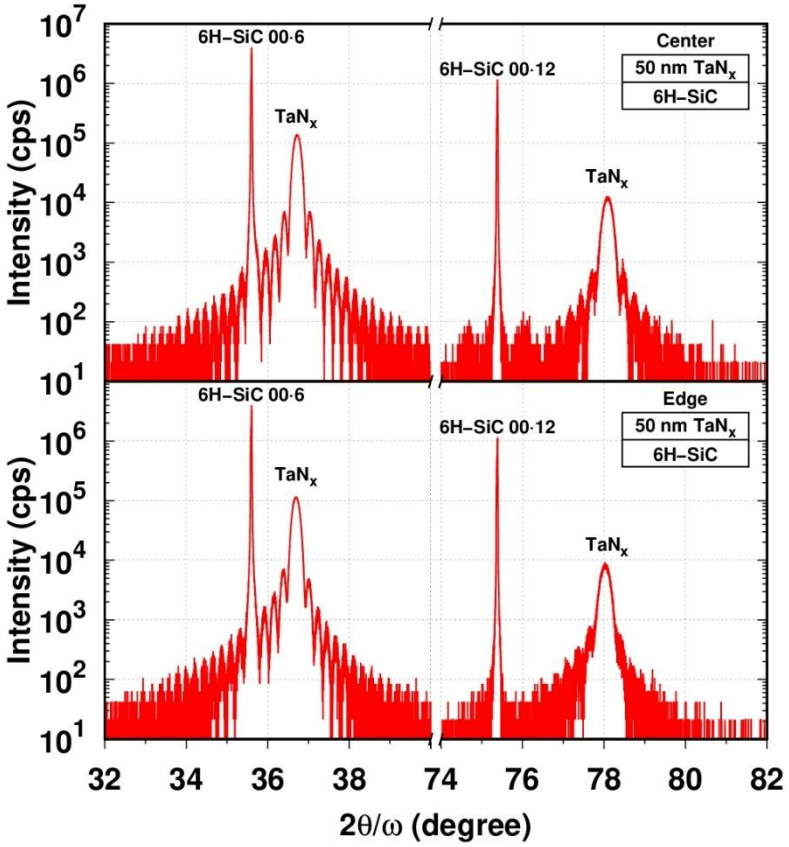

Figure 2. Symmetric 2θ/ω x-ray diffraction scan of a 50 nm thick TaN_x film on 6H-SiC. Uniform, single phase TaN_x is indicated across the 3-inch diameter substrate. Pendellösung fringes around the TaN_x peak indicate smooth and sharp interfaces. The TaN_x phase is tentatively identified as hexagonal β-Ta_2N (space group $P6_3/mmc$).