Ternary Thin Film Alloys for Varistor Application

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In this work we propose to employ atomic layer deposition (ALD) grown thin films of $Ti_xSi_yN_z$ as a universal heating electrode for integrated electronic devices. In this work the Ti:Si ratio and film thickness were varied, and corresponding structural and physical analysis was performed using multiple characterization techniques. By varying the Si fraction in the film, wide range of resistivity was achieved. Atomic level control of Ti:Si fraction in the films enabled fine tuning of the morphology from polycrystalline to fully amorphous with optimum resistivity. The $Ti_xSi_yN_z$ films were grown using Eugenus 300 mm QXP commercial mini-batch ALD reactor. X-Ray diffraction (XRD), high resolution transmission electron microscopy (HRTEM), and selected area electron diffraction (SAED) of these films corroborated transition from nano-crystalline to pure amorphous phase with increase in Si concentration (Figure 1). $Ti_xSi_yN_z$ films processed in our labs have already exhibited superior diffusion barrier properties and stability of the resistivity of the films. Our recent work on the in-situ high temperature XRD studies of the $Ti_xSi_yN_z$ films showed superior phase stability of the $Ti_xSi_yN_z$ films at high temperatures of 800°C with negligible alteration in recrystallization (Figure 2). Nanoindention based hardness studies of these films indicated the change in mechanical properties with varying Si% in the TiN matrix. The sub-nanometer level of surface roughness of these $Ti_xSi_yN_z$ films as established by Atomic Force Microscopy would also benefit adhesion of our $Ti_xSi_yN_z$ films with other electronic materials yielding coherent interfaces.

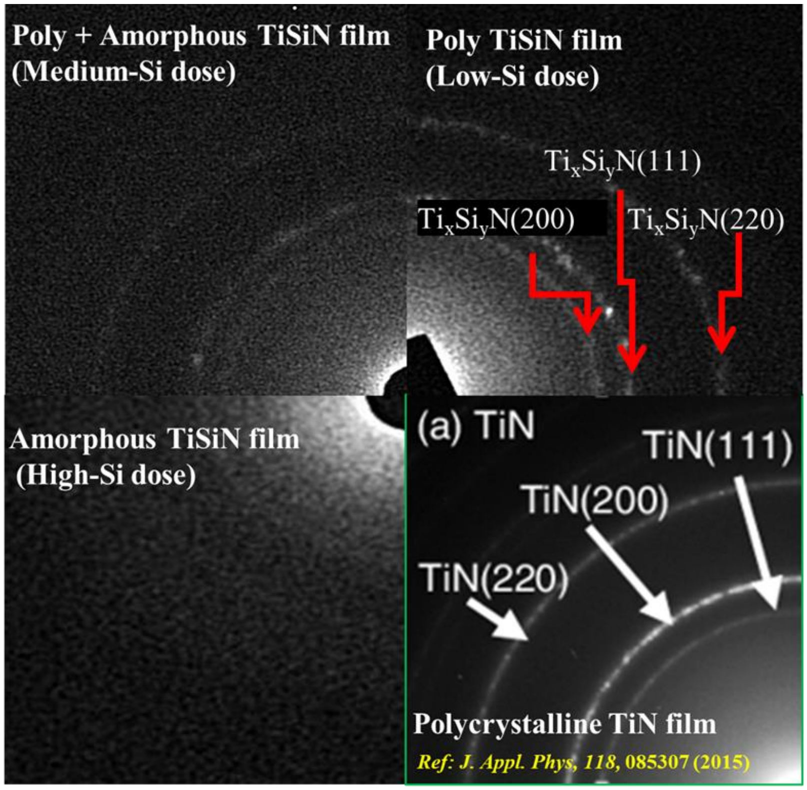

Figure 1: Selected Area Electron Diffraction of TiSiN Thin Films with Varying Si Fraction

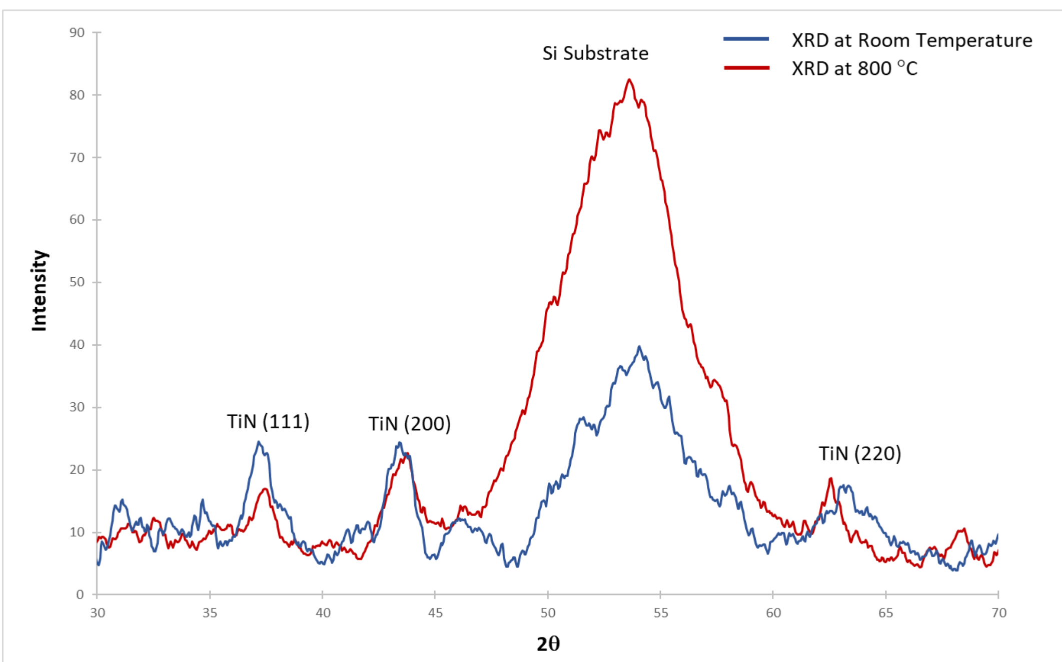

Figure 2: Glancing Angle X-ray Diffraction of $Ti_xSi_yN_z$ films at Different Temperatures