Ternary thin film alloys of Ti-Si-N as low resistance diffusion barrier for Memory Applications

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The rapid advances in memory technology, coupled with decreasing feature sizes and increasing aspect ratios, have imposed stringent requirements on the physical and electrical properties of metal-to-semiconductor interfaces. This has resulted in several integration and material challenges for low-resistance contacts and diffusion-barrier films. Reactively-sputtered titanium nitride (TiN) is widely used as diffusion-barrier layer due its high thermal and chemical stability, low electrical resistivity, and process maturity. However, the columnar and polycrystalline grain structure provides a pathway for diffusion during higher-temperature anneal steps. This undesirable effect, which leads to device degradation and failure, has led to the search for alternative films. In this work, we report recent advancements on the amorphous ternary alloy films composed of titanium, silicon and nitrogen (TSN), an excellent alternative to TiN films. These TSN films were grown using Atomic Layer Deposition (ALD) technique on the Eugenus 300mm QXP commercial reactor. In order to understand the feasibility and tunability for a variety of applications, the films were grown over a wide temperature window of 400-620°C and using several different chlorine-based Si precursors. Film thickness and silicon content were varied and corresponding electrical characterization was performed. X-ray photoelectron spectroscopy and Rutherford Back Scattering techniques were utilized for compositional analysis. The results indicate that ALD-based TSN films are not only high volume manufacturing compatible, but have excellent mechanical, thermal and electrical properties and are scalable to the next technology nodes.

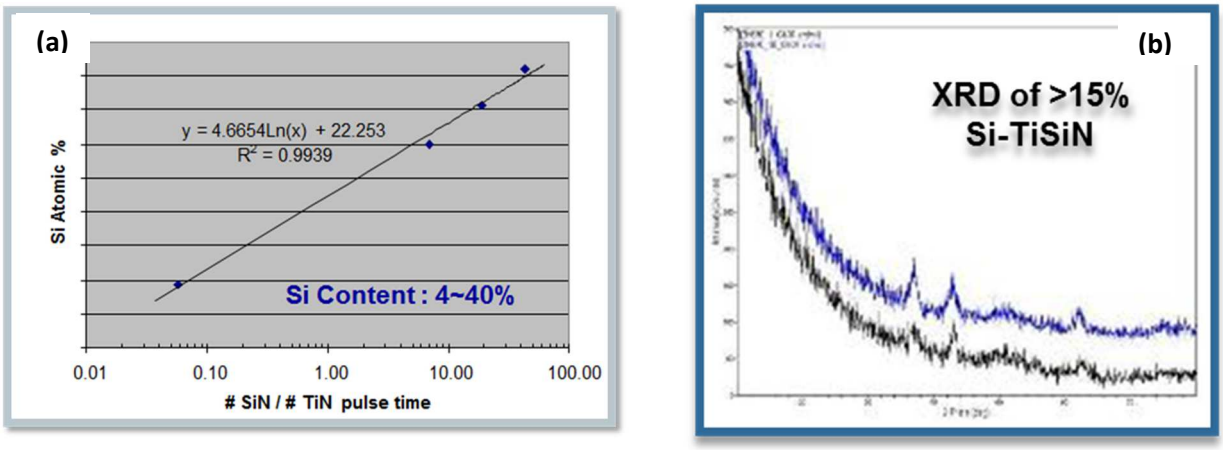

Fig. 1 : (a) Variation of % of Si in TiSiN films for Precursors 1 with respect to ALD Pulse ratio. (b) XRD of same films from Precursor 1 showing amorphous characteristics by XRD for TiSiN films with >15% of Si. Amorphous films exhibits better diffusion barrier properties.