Epitaxial CVD Ruthenium for High-Performance Interconnects at A7 and Beyond

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Ruthenium is projected to replace Cu in A7 node or beyond, likely bringing back subtractive integration that Cu replaced with damascene almost 3 decades ago. To enable this transition, integration of Ru interconnect metal lines and vias with lower resistivity need to be demonstrated. Ru thin films with very low resistivity (~8 μΩ-cm at 30nm; bulk =7.4 μΩ-cm) has been reported [1], by depositing epitaxial PVD Ru on Si (111) with buffer layers like AlN (001). Layer transfer approach has been proposed for integration of such epitaxial Ru [1]. PVD epi-Ru can be suitable for interconnect metal lines through patterning and direct metal etch. However, it may not be ideal for via, even though some integration approaches explore to use it. CVD via filling remains an attractive integration approach for via metal [2]. Here we demonstrate epitaxial CVD Ru for selective via filling (Fig 1).

In this study, we used epitaxial PVD Ru (6 and 8 nm)/AlN (001)/Si(111) as substrates for CVD Ru experiments conducted in a CVD reactor. A series of preclean steps was applied to eliminate surface oxides and refresh the surface before CVD Ru growth under different deposition conditions. Powder XRD patterns (2θ-ω scans) show only Ru (*00l*) peaks, indicating CVD Ru film growth along *c*-axis. Representative CVD Ru film growth is shown in Fig 2. Laue oscillations at the bottom of Ru (002) peak are signature of epitaxial film growth. The Ru (101) Φ-scans collected at χ=61.3º show six-fold symmetry (Fig 3), like the underlying PVD epi-Ru, further confirming epitaxial CVD Ru film growth [1]. This paper will summarize systematic studies of CVD Ru film growth on PVD epi-Ru and characterizations including microstructure and electrical properties.

References:

1. C. Adelmann et.al, Epitaxial Ruthenium for Advanced Interconnects, IITC (2025) P32.
2. M. H. van der Veen, et. al, Selective Deposition and Ruthenium Superfill Exploration Beyond A10 Node Interconnects, VLSI Symposium (2025), T18-3.

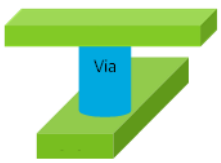

Figure 1. Schematic of epi-Ru interconnects

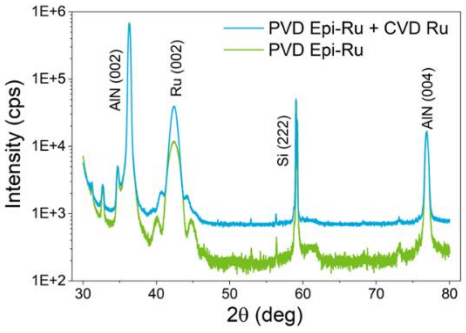

Figure 2. Powder XRD Patterns. Laue oscillations of Ru (002) confirm epitaxial crystalline films with sharp interfaces.

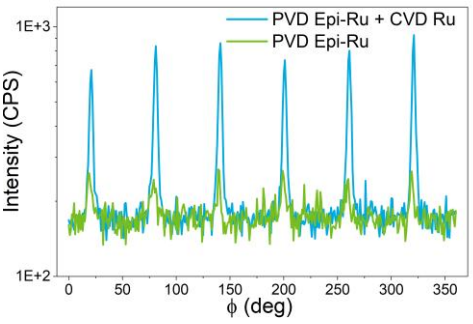

Figure 3. Ru (101) Φ scans at χ=61.3º showing six-fold symmetry.