Optical models of Cu films of 75 nm nominal thickness which are used to interpret ellipsometry and reflectance measurements can be enhanced by information obtained using X-ray Diffraction (XRD) and X-ray Reflectivity (XRR). XRD measurements were made in three configurations using a Rigaku SmartLab system: 1) standard Bragg-Brentano, 2) grazing incidence, and 3) in the plane of the film.

Thin metallic films were deposited simultaneously on a Si(100) substrate with a thin native oxide layer and a Si(100) substrate with 500 nm of amorphous thermal SiO$_2$. A thin (3 nm) adhesion layer of Cr was sputter deposited on both samples followed by a 75 nm layer of Cu. The Cu layer was sufficiently thick and absorbing that these samples were optically thick in the visible part of the spectrum and the Cr layer and underlying substrates were not visible. Ellipsometry and reflectance measurements indicated that the two Cu films were not identical although they were both similar to fully dense Cu. The Cu on Si film could be well modeled assuming approximately 1.8 nm of surface roughness in a layer that was about 55% Cu and 45% void. The Cu below this was fully dense. The Cu on SiO$_2$ on Si film however, could not be well modeled using simple ellipsometry models.

XRR measurements on both films looked very similar and indicated that the films were fully dense Cu with a rough layer of 1.6 – 1.9 nm at the surface. Kessing fringes from the underlying Cr were detected but no fringes from the Cu layer were observed. This is believed to arise from a combination of surface roughness and film thickness non-uniformity. Reducing the radiated area of the sample in an attempt to minimize film thickness non-uniformity did not result in the appearance of fringes. XRD measurements demonstrated that the two films had very different crystalline orientations. This was particularly evident in the in-plane measurement which showed much stronger Cu(200) and Cu(220) peaks for the Cu on SiO$_2$ on Si sample compared to the Cu on Si sample. This additional information was used to further enhance the optical models for interpreting ellipsometry and reflectance measurements.