Mass Absorption Coefficient of Tungsten, 1600-2100 eV

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Introduction

Recently, the Synchrotron Radiation Instrumentation Collaborative Access Team (SRI-CAT) beamline 2-ID-B has been used to image Al, Cu, and W integrated circuit interconnects in both 2-D and 3-D. Interconnect thickness information may be obtained from 2-D images if the x-ray attenuation is measured and the mass absorption coefficients are known. Good contrast may be obtained in images of interconnects near 1800 eV. However, the mass absorption coefficient of tungsten in particular had previously been measured only with line sources and never directly across the M_V and M_{IV} edges.

Methods and Materials

Two thin films of tungsten were grown by using ion-assisted deposition with 400-eV Ar ions. The sample thicknesses were approximately 52 and 108 nm. The intensity of x-rays passing through each sample was measured for photon energies between 1600 and 2100 eV with an energy resolution of 3 eV, as determined by the beamline 2-ID-B spherical grating monochromator. The ratio of the transmitted intensities gives the transmission of the sample. By using two samples, the method is relatively immune to variations in the efficiency of the beamline as well as the state of the surface of the films. (The films had nearly identical histories.)

Results

We found that the widths of the M_V and M_{IV} edges were 33 and 28 eV, respectively. Since most tabulations indicate a zero width, the standard values would necessarily be misleading. A good account of the widths was given by a real-space multiple-scattering program known as FEFF 8.10 as well as by an atomic program with dynamic screening in the relativistic time-dependent local density approximation (Fig. 1).

Discussion

While the M_V and M_{IV} edges are well accounted for within the FEFF calculation, the pre-edge region is not. Moreover, FEFF predicts x-ray absorption fine-structure features of about 5% in size. The leading uncertainty in the measurement was the mass thickness difference of the samples. In 2002, we hope to remeasure with new samples with improved characterization to explore these features. We also hope to extend the work to tantalum, another important material in integrated circuit interconnects, which is even less explored in the literature than is tungsten. A further goal is to observe tungsten and tantalum *in situ* in integrated interconnect samples.

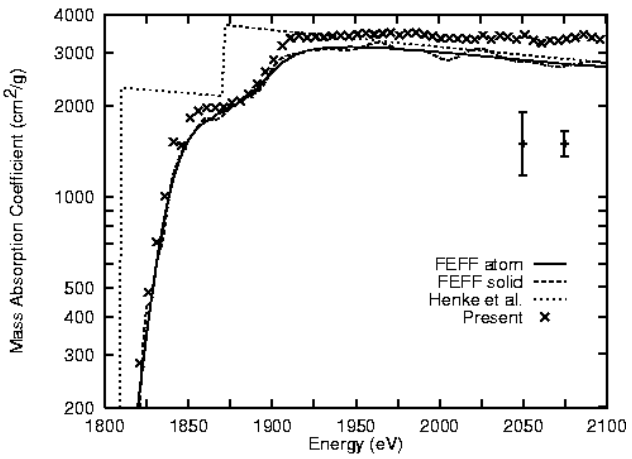

FIG. 1. The mass absorption coefficient attributable to M-shell absorption (resonance or electronic ejection into the vacuum) from present experiment (X), an x-ray table, and present FEFF calculation.

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Reference

Z. H. Levine, S. Grantham, and I. McNulty, Phys. Rev. B **65**, 064111-064116 (2001).