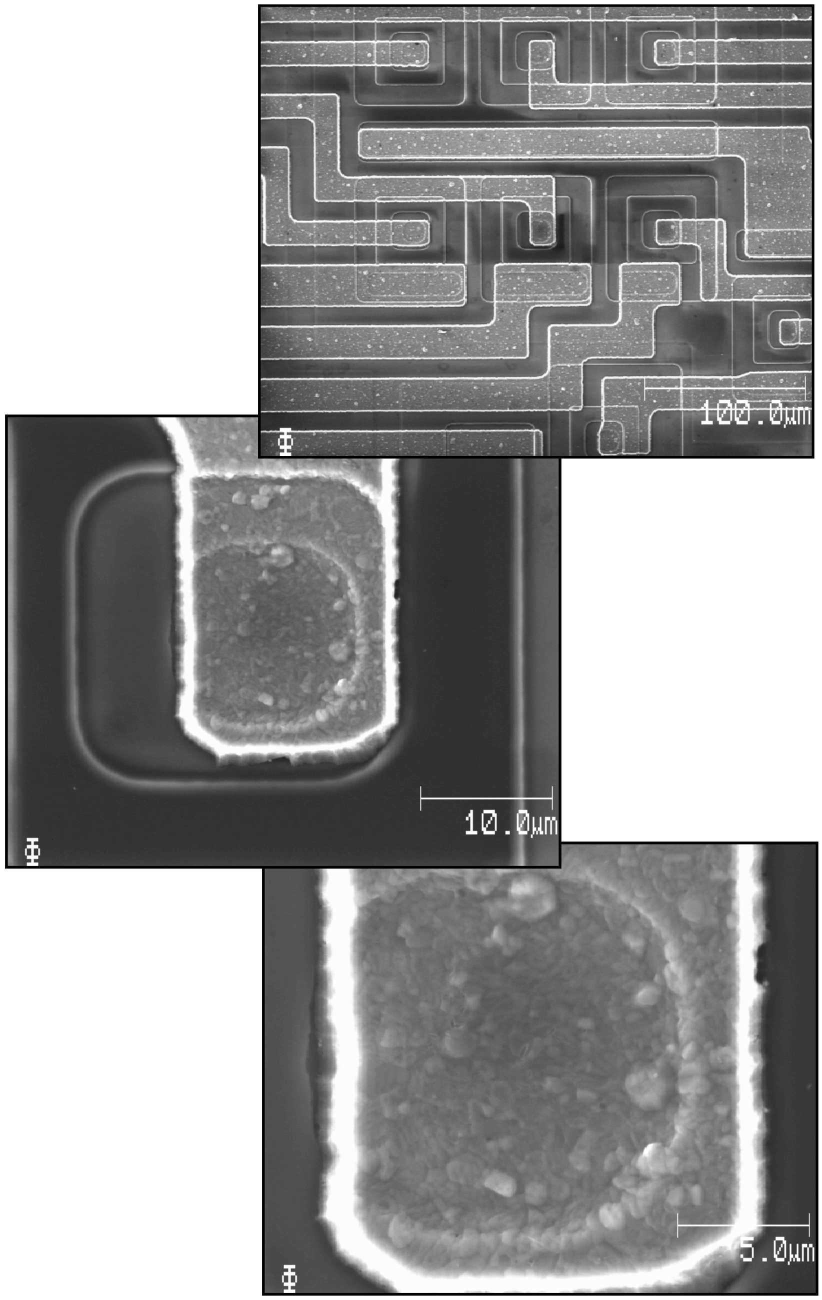
PHYSICAL ELECTRONICS
A DIVISION OF ULVAC-PHI

Compucentric Zalar Depth Profile of a 10 µm Al Bond Pad

Auger Electron Spectroscopy (AES) is a surface analysis technique widely used in conjunction with inert gas ion sputter etching for materials characterization of multilayer thin films. Zalar Rotation™ during sputter profiling has been shown to dramatically improve depth resolution by minimizing surface roughening and reducing cone formation. This is accomplished by rotating the sample during ion sputtering such that the surface is sputtered from all azimuthal angles, minimizing ion shadowing and crystallographic or granular sputter dependencies.

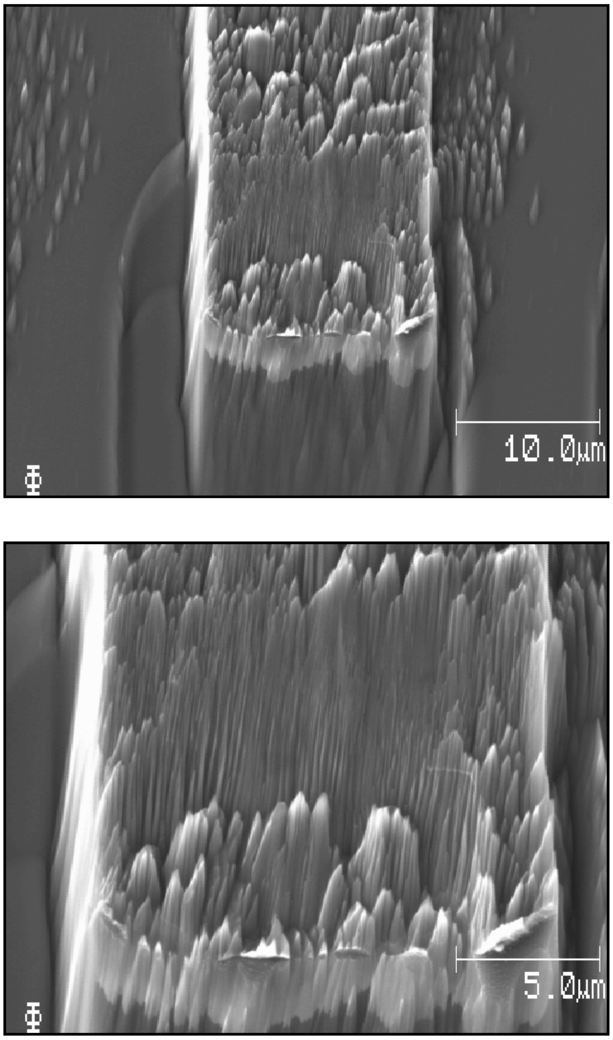
During Zalar Rotation, it is necessary to keep the analyzed area within the ion sputter crater. This requirement has previously limited the types of samples used for Zalar Rotation sputter profiles to blanket films or large uniform structures that can be positioned directly over the stage rotation axis. The PHI Scanning Auger Nanoprobes overcome this limitation by providing Compucentric Zalar Rotation during sputtering. This allows the acquisition of Zalar depth profiles on specific features which do not reside directly over the stage rotation axis.

Compucentric Zalar Rotation is made possible by the computer-controlled and fully-motorized 15-680 stage. The stage control software reads the position of the analyzed area relative to the rotation axis and makes x and y axis corrections during sample rotation to keep the analyzed area within the sputter crater. After a Zalar rotation cycle, the stage returns to the home position to accurately align the analyzed area for acquisition of Auger data.



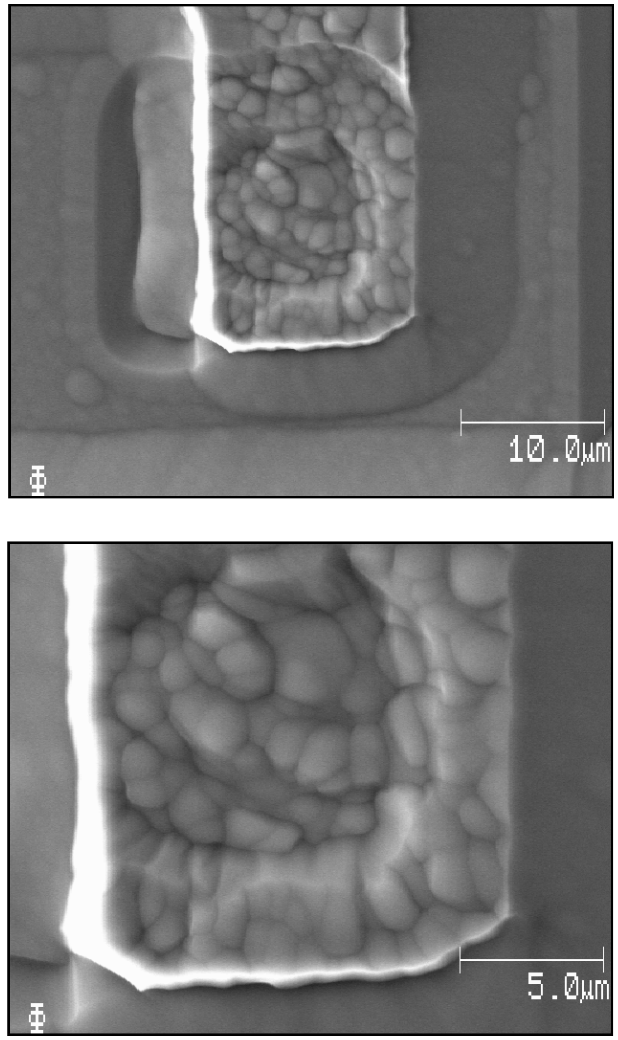
These secondary electron images show the as-received Al vias, which are approximately 10 µm across. Two sputter depth profiles, one with Compucentric Zalar Rotation and the other without, were taken on two separate vias.

Secondary Electron Images



Without Zalar Rotation

These secondary electron images show an Al via during the sputter depth profile without Zalar Rotation. Note the severe cone formation tilted in the direction of the incident ion beam. In these images, the lighter material is Al and the darker material is Si.

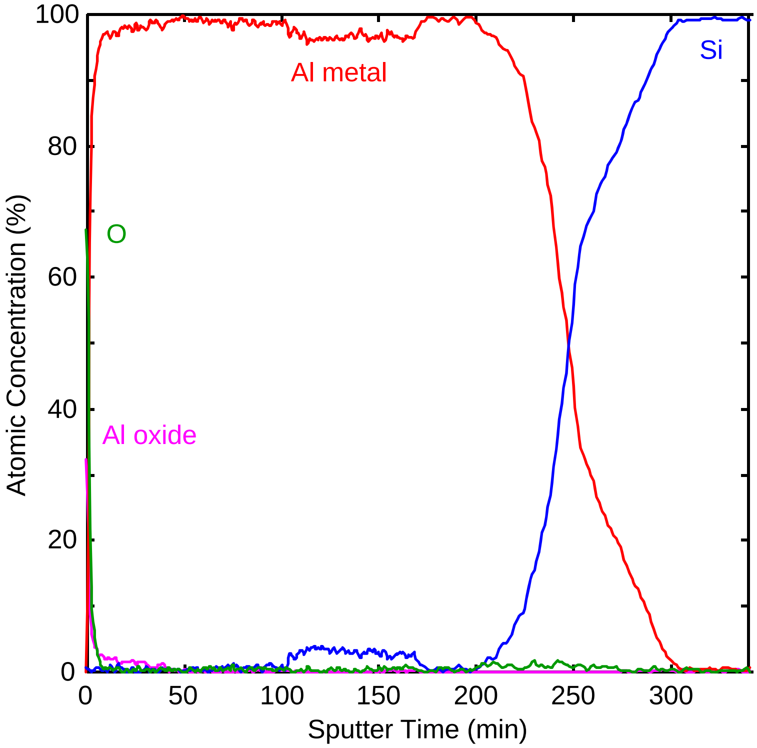


With Zalar Rotation

These secondary electron images show an Al via after the Compucentric Zalar Rotation sputter depth profile. Note the lack of cone formation and the clearly-defined contact structure, which has been transferred into the Si substrate, indicating uniform layer-by-layer sputter removal. The topography observed at the Al position results from the grain structure in the overlying Al film.

It is often necessary to determine the layer composition or interfacial contamination within metallization structures such as vias and contacts during semiconductor device characterization or failure analysis. One effect of interfacial contamination is high contact resistance, which often occurs only on specific features. Aluminum (Al), a common conductor used in semiconductor devices, is particularly prone to cone formation during sputter etching. Therefore, Al vias were used to compare the depth resolution and surface morphology of sputter profiles obtained with and without Compucentric Zalar Rotation.

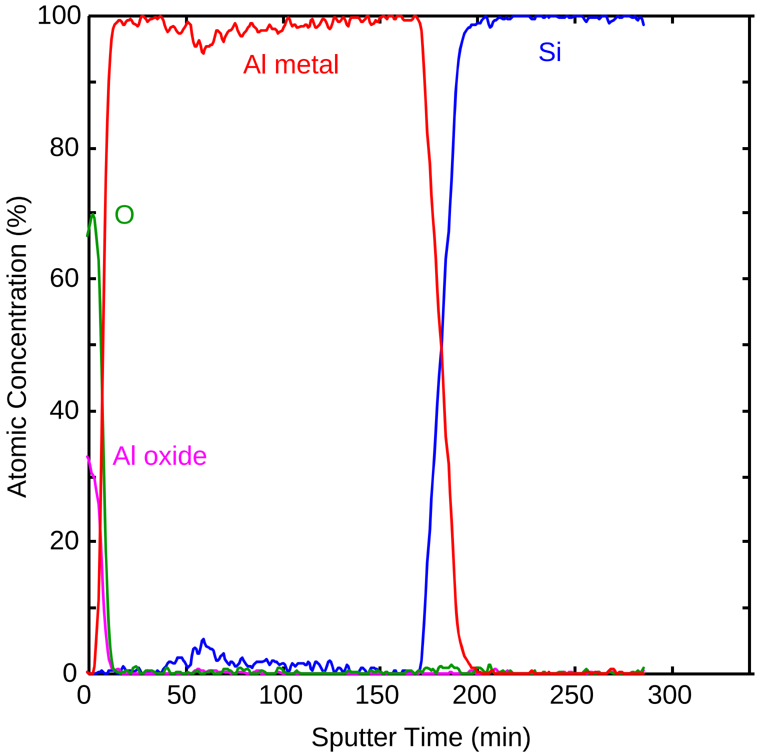
Sputter Depth Profiles



Sputter depth profiles obtained with and without Zalar rotation are shown here. The profile obtained without rotation shows that the Al/Si interface has been dramatically broadened because of the surface roughness introduced by sputtering. The sputter depth profile obtained with Zalar rotation has a much sharper Al/Si interface.

Without Zalar Rotation

Linear least squares fitting, available in PHI MultiPak,™ has been used to separate the Al profiles in both the Zalar and non-Zalar depth profiles into two chemical components. The first component is Al oxide found on the surface of the Al pad, and the second component is metallic Al. The Al/Si interface appears to be clean and abrupt in this example.



With Zalar Rotation

It is clear from a comparison of these two profiles that the depth resolution obtained using Compucentric Zalar rotation is dramatically superior. This improved depth resolution provides better definition of buried thin layers, permits a better measurement of possible interdiffusion or reaction between layers, and enables a more definitive determination of possible interfacial contamination to be achieved on specific off-axis features.

Physical Electronics USA, 18725 Lake Drive East, Chanhassen, MN 55317
Telephone: 952-828-6200, Website: www.phi.com

ULVAC-PHI, 370 Enzo, Chigasaki City, Kanagawa 253-8522, Japan
Telephone 81-467-85-4220, Website: www.ulvac-phi.co.jp