TN 101

EAGLABS^{SM} Auger Electron Spectroscopy (AES) Services

Technique Note

October 14, 2008 (Version 2.0)

AES provides excellent surface sensitivity and small analysis size

Introduction

Auger Electron Spectroscopy (AES) is a analytical technique used to determine the elemental composition of the top few atomic layers (~5-10nm depth of analysis) of features as small as ~25nm. This technique is widely used to identify the composition of sub-micron sized particles and defects. AES can detect all elements except H and He and provides semiquantitative information with detection limits of 0.1 to 1 atomic percent for most species. AES is normally used for analyzing conductive and semiconductive solids, although some insulating materials can also be analyzed. When used in combination with an ion sputter source, AES can perform small-area compositional depth profiling, and when used in combination with Focused Ion Beam (FIB), it is useful for analyzing cross sectioned samples.

Principles

The Auger technique (named after Pierre Auger, who described this process in 1925) uses a primary electron beam typically in the 3 to 25 keV range. Atoms that are excited by the electron beam can relax through the emission of Auger electrons. The kinetic energies of the emitted Auger electrons are measured and are characteristic of elements present at the surface of a sample. The resulting spectrum is usually plotted as the derivative of the signal intensity vs. kinetic energy, with each element showing a unique "fingerprint" for elemental identification. The electron beam can be rastered over a large or small surface area, or it can be directly focused on a small surface feature. This scanning electron beam also generates secondary electron (SEM) images that are used to locate the features of interest. Auger maps and linescans show the lateral distribution of elements on a surface, while depth profiles can reveal the composition as a function of depth.

Common Applications

Auger's high spatial resolution capabilities and surface sensitivity make it the technique of choice for the following types of applications:

- Analyzing sub-micron particles to determine contamination sources
- Identifying defects in electronic devices to investigate failure causes
- Determining the oxide layer thickness of electro-polished devices
- Small-area depth profiling of bond pads on die
- Mapping of elemental distribution on discolored or corroded regions
- Cross-sectional analysis of buried defects in film stacks
- Identifying grain boundary contamination in metal fractures, fatigues and failures
- Integrity and uniformity of thin film coatings such as diamond-like-carbon (DLC)

Strengths

- High Spatial Resolution: <10nm minimum spot size
- Surface Sensitive; top 5-10nm
- Identification of all elements except H and He
- 2-D and 3-D elemental distribution of small areas
- Rapid analysis for elemental composition
- Can analyze up to 300mm wafers

Limitations

- Minimal chemical state information
- Insulators are difficult
- Samples must be vacuum compatible
- Detection limits of ~0.1% to 1% atomic

Technique Comparisons

Other analytical techniques that provide complementary information with AES, but with varying limitations, include XPS/ESCA (X-ray Photoelectron Spectroscopy) and EDS (Energy Dispersive X-ray Spectroscopy).

XPS is a surface sensitive technique that provides short-range chemical bonding information from the top 5-10nm of the surface. However, XPS has a minimum beam size of about 10µm, whereas AES has a minimum beam size of less than 10nm. The strength of XPS is the chemical information available from the spectra, while AES provides mainly elemental composition with limited chemical information. Insulating materials, including organic compounds, are routine for XPS, but are difficult for Auger.

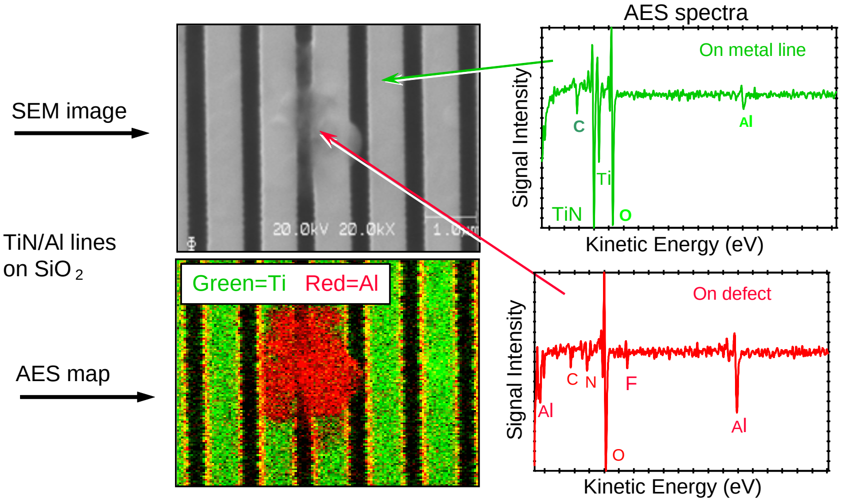
Similar to AES, EDS also uses a focused electron beam to generate the analysis signal, but the sampling volume for EDS (~0.5µm wide by a few µms deep) is much larger than AES. The smaller sampling volume of AES offers advantages over EDS for the analysis of sub-micron particles and thin films. The Auger process is favored in lower atomic number elements over the emission of x-rays for EDS, making AES more sensitive than EDS for the analysis of lighter elements, such as B, C N, O, and F.

AES at Evans Analytical Group

EAG has 9 AES instruments located throughout the world. Some of these instruments contain special capabilities such as in-situ fracture stage for metallurgical applications, and the capability to analyze 200mm and 300mm wafers under clean room conditions. FIB (Focused Ion Beam) capabilities on some of our Auger systems aid in the preparation and analysis of cross-sectioned samples. Our AES experience is unsurpassed with our AES scientists having an average of over 14 years experience.

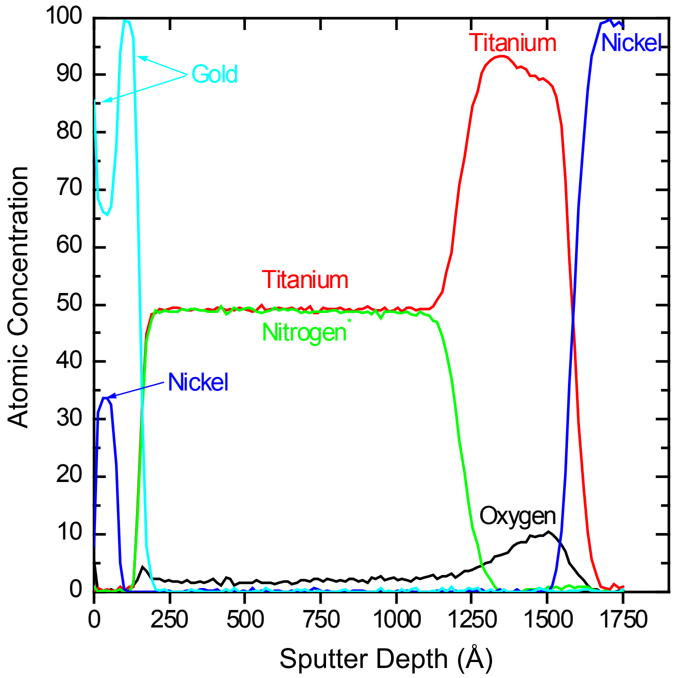
Typical Data

Thin Contamination Layer



Auger analysis shows the thin residue is an Al flake, probably originating from the etch chamber.

Decorative Coating Defect



AES sputter profiles provide compositional information as a function of depth