**Auger Electron Spectroscopy (AES)**

**Physics of AES:**

Auger Electrons were discovered in 1925 but were used in surface analysis technique in 1968. Auger Electron Spectroscopy (AES) is a very effective method now-a-days for surface analysis technique. Auger electron is produced in a two-step process by interaction of an atom with incident radiation—photons, electrons, ions, or neutral atoms. In step 1 an external electron removes the core electron generating a core hole and in step 2 the core hole is filled up by another electron from higher energy level resulting an Auger electron generation with the excess energy. Figure below clearly illustrate the steps of Auger electron generation-

![Diagram A](image1)

(a) L₂,₃ or 2p  
L₁ or 2s  
Photon  
Photoelectron  
K or 1s

![Diagram B](image2)

(b) Auger electron  
L₂,₃ or 2p  
L₁ or 2s  
K or 1s

Fig 1: Auger Electron Generation (a) Step 1 and (b) Step 2

The kinetic energy for the Auger electron,  
\[ E_{ke} = E_k - E_{L2,3} - \phi = E_k - 2E_{L2,3} - \phi \]
Here, $\phi$ is the work function of the sample and $E_{\text{suffix}}$ represents energy at different level. In Auger analysis at least three electrons are required which excludes hydrogen and helium.

**Example:**

One example was taken from a paper which reports high lateral resolution Auger electron spectroscopic (AES) measurements on high aspect ratio tin (Sn) whiskers. The Auger spectrometer which was used in this experiment was a Physical Electronics PHI 680 field emission nanoprobe instrument containing a cylindrical mirror analyzer operating at a base pressure of $\sim 1 \times 10^{-10}$ Torr. Initially significant electron-beam damage to whiskers was found while the electron beam voltage was 10 KeV (10 nA). Therefore the beam energy was reduced to 5 KeV (8 nA) for minimizing the damage of the whisker. The tilt angle for the specimen was 30°.

**Sample Preparation:**

Sputter cleaning was done for the whisker surfaces using a duoplasmatron sputter ion source operating with Ar at 2 kV, 1-A and using a 2x 2 mm$^2$ raster, with a sputter rate of $\sim 50\text{Å}/\text{min}$ measured on a standard SiO$_2$ film. $E \cdot N(E)$ integral mode was employed in collecting the raw auger data by recording the spectrum of electrons emitted from the surface from an energy 30-1000 eV with a starting energy of 50 eV to avoid collecting data from the intense, broad secondary electron peak occurring in this energy region. For smoothing the data and calculating the derivative Auger spectrum Savitsky-Golay algorithm was employed. Relative Auger sensitivity factors provided by the manufacturer were used to determine the surface elemental composition. The brass substrate having composition Cu (60 wt %) and Zn (40 wt %), cut into several square pieces of dimensions 1 cm x 1 cm x 0.25 mm for use in this work. Using a standard magnetron sputtering system operating with various gas pressures of Ar, the Sn thin films were grown on brass. After this, the samples were stored at atmospheric pressure at room temperature for several weeks until long, high aspect ratio Sn whiskers were grown. Immediately it was sputter cleaned to create an atomically clean Sn surface and stored under UHV on a docking module within our Auger system.
Fig- Auger analysis at (left fig) the root of the whisker shaft and (right fig) the adjoining Sn surface

Fig - Auger analysis at the end of the whisker shaft.
Fig - Auger analysis as a function of depth into the whisker.
Discussion:
The whiskers were grown from compressively stressed thin films of Sn on brass by magnetron sputtering system. After sputter cleaning, it is obvious from the Auger spectra that the whisker is nearly 100% Sn at all locations along the whisker shaft, at the growing blunt end of the shaft, and with depth into the side of the whisker. The tin whisker surface demonstrate the desired expected ~ 200Å° of native Sn oxide at all locations and the O signal nearly disappeared (~ 3 atom %) after 200Å° of sputter cleaning. Oxygen amount was negligible within the bulk amount of whisker. Nowhere brass was observed in the whisker shaft which supports the notion that whisker formation is accompanied by material mass transport through interfaces and grain boundaries which causes stress relief.

References:
