MSE 310 Lecture 13
Auger Electron Spectroscopy

Auger Electron Spectroscopy (Auger spectroscopy or AES) was developed in the late 1960's, deriving its name from the effect first observed by Pierre Auger, a French Physicist, in the mid-1920's. It is a surface specific technique utilizing the emission of low energy electrons in the Auger process and is one of the most commonly employed surface analytical techniques for determining the composition of the surface layers of a sample.

The Auger effect is a phenomenon in physics in which the transition of an electron in an atom filling in an inner-shell vacancy causes the emission of another electron. When an electron is removed from a core level of an atom, leaving a vacancy, an electron from a higher energy level may fall into the vacancy, resulting in a release of energy. Although sometimes this energy is released in the form of an emitted photon, the energy can also be transferred to another electron, which is ejected from the atom. This second ejected electron is called an Auger electron.

An electron energy analyzer is used to measure the energy of the emitted Auger electrons. From the kinetic energy and intensity of an Auger peak, the elemental identity and quantity of a detected element can be determined. In some cases chemical state information is available from the measured peak position and observed peak shape.

(AES) is a nondestructive core-level electron spectroscopy for semi-quantitative determination of the elemental composition of surfaces, thin films, and interfaces. The popularity of this ultrahigh vacuum technique may be attributed to high surface sensitivity (an analysis depth of less than 100 Å) and a relatively low detection limit (~0.1 atomic percent). In addition to having an elemental coverage from lithium to uranium and beyond, AES has the ability to distinguish between two elements that are close to each other in the periodic table. In addition, AES has an atomic number dependent sensitivity that varies at most by one order of magnitude.

Principle of AES

•A fine focused electron beam bombards the sample and ejects an electron of the inner shell of the atom.

• This vacancy must be refilled by an electron from a higher energy level. • When the higher energy electron fills the hole, the release of energy is transferred to an electron in an outer orbit electron.

• That electron has sufficient energy to overcome the binding energy and the work function to be ejected with a characteristic kinetic energy.

•The ejected electron is referred to as an Auger electron after Pierre Auger

- The Auger process require three electrons, thus we cannot detect H and He but can detect all other elements from Li or up

Auger spectroscopy can be considered as involving three basic steps :

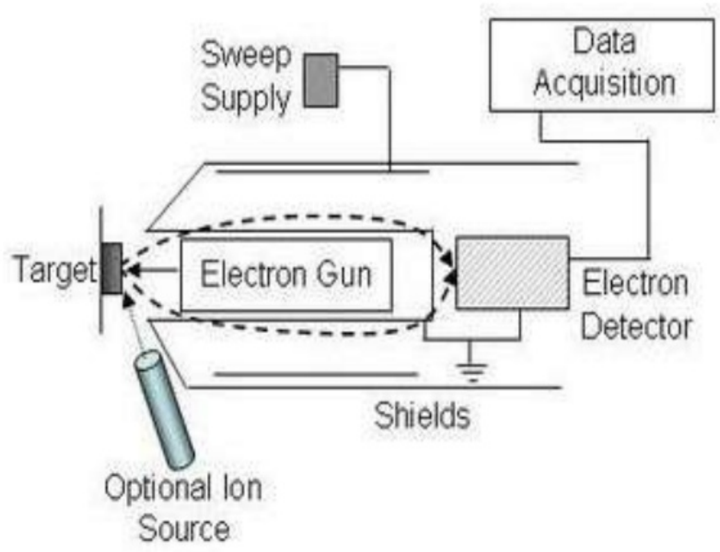
(1) Atomic ionization (by removal of a core electron)

(2) Electron emission (the Auger process)

(3) Analysis of the emitted Auger electrons

Instrumentation

The sample is irradiated with electrons from an electron gun. The emitted secondary electrons are analyzed for energy by an electron spectrometer. The experiment is carried out in a UHV environment because the AES technique is surface sensitive due to the limited mean free path of electrons in the kinetic energy range of 20 to 2500 eV



As a surface-sensitive technique, AES requires an ultra-high vacuum (UHV) environment to maintain an uncontaminated surface during data acquisition. As a general rule, if every contamination atom in the vacuum system that hits the sample surface sticks to it, then at 10^{-6} torr (1.3×10^{-4} Pa) one monolayer of contamination will be deposited in one second. Auger analysis of such a surface would reveal only the contamination layer, not the original surface elements. To minimize contamination during analysis, base pressures in the 10^{-10} torr (1.3×10^{-8} Pa) range are typically required.

In addition to a UHV chamber, an Auger system includes an electron source and an optical column to produce a focused incident electron probe for specimen excitation, a secondary electron detector for SEM imaging, an electron energy analyzer and detector for the collection and measurement of emitted Auger electrons, and a sample manipulator to locate the area of interest at the focal point of the Auger analyzer.

Summary

Auger electron spectroscopy has been a powerful surface analytical technique in the areas of semiconductors and metallurgical materials for four decades. With enhancements in spatial resolution, high-stability systems for imaging, and atomic-layer depth profiling with low-energy Ar ions, AES has evolved into a valuable chemical characterization technique for nanowires, nanocones, and other nanostructures.