Auger Electron Spectroscopy

Auger Electron Spectroscopy (AES) is a technique used to study material surfaces in order to find the identity and quantity of the elements present in the material. AES uses a primary electron beam to examine the surface of a solid material. Secondary electrons that are emitted as a result of the Auger process are analyzed and their kinetic energy is determined. The identity and quantity of the elements are determined from the kinetic energy and intensity of the Auger peaks.

The Auger effect consists of the following process: A gun shoots a beam with x-rays, electrons, photons, etc. into the surface of the material. The x-rays hit the atoms in the material, which because of the radiation emitted, enters an excited state and it loses an electron from one of its shells. In order to neutralize or de-excite the atom; an electron transition from a higher level shell to the empty space left by the ejected electron must occur. This transition produces another type of radiation that is either ejected out of the material or is absorbed by another electron in the atom, which in turn will get excited and eject out of the material as an Auger electron.

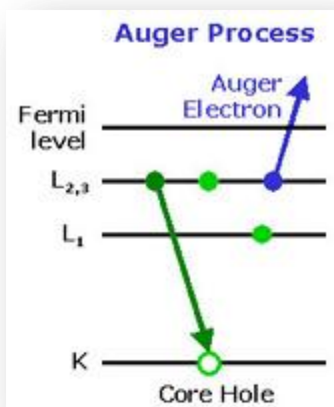

Fig. 1. AES Process

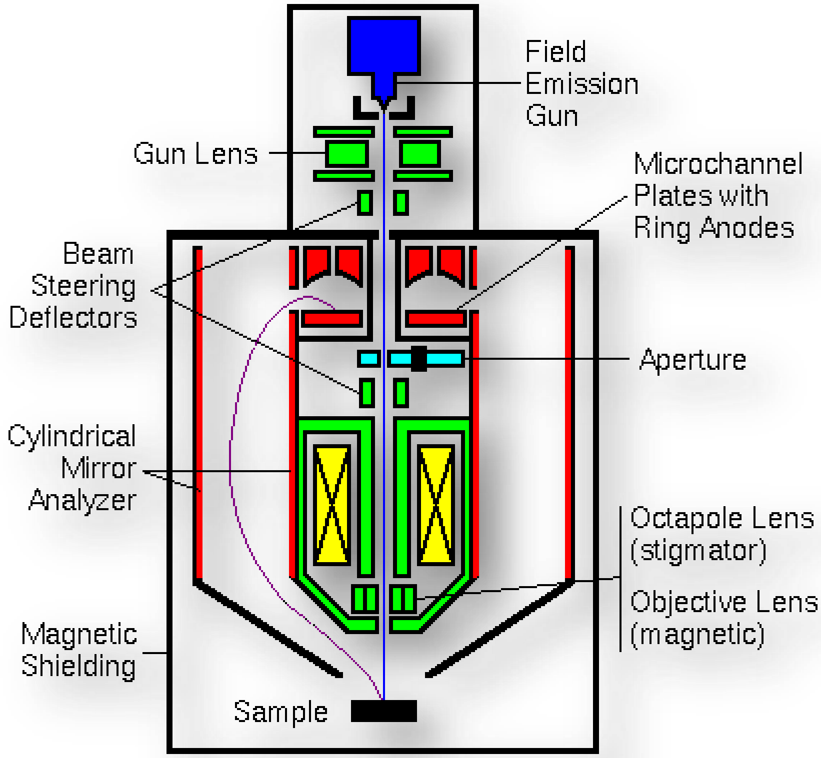

Fig. 2. Instrumentation

AES is used determine the elemental composition of material surfaces. This process is a non-destructive analysis technique. This technique can study surfaces and grain boundaries of materials. It has a depth of penetration of up to 5nm. Surface contamination can be analyzed with this technique.

Characteristics	AES
primary beam	electrons
analyzed beam	electrons (energy)
Type of sample	conductive
area of analysis	10nm
surface selectivity	1 to 5 nm
elemental identification	all except H and He
sensitivity	0.10%
nature of chemical bombarding	shift and shape
depth profiling	elemental, chemical
destructive nature	none if not sputtered

Table 1. Characteristics of AES

Example:

Application of AES Line Shape Analysis for the Identification of Interface Species During the Metallization of Diamond Particles

Diamonds are mainly implemented into cutting tools due to their hardness, but they are also used as a heat-sinks for high-power GaAs device chips. This is due to their excellent thermal conductivity. However, it is very difficult to obtain a strong adhesive force between diamond and the metal substrates, due to the inertness of diamond. Therefore the metallization of diamond is an effective way to improve the contact performance between the diamond and metal substrate.

In this paper, the interface diffusion between metallic layers and diamond particles was measured using AES depth profile analysis. The chemical states and the interlayer species on the interface were revealed using AES line shape analysis.

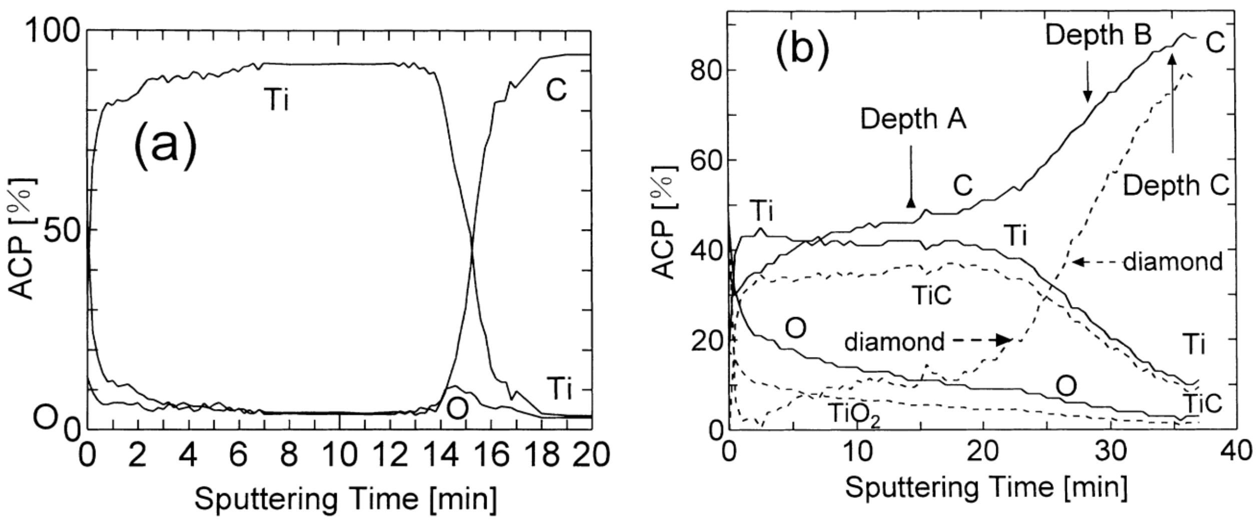

Figure 1. The depth profile spectra of a Ti layer/diamond sample before and after annealing in a high vacuum: (a) before annealing; (b) after annealing at 600 °C for 4 h.

When comparing Fig. 1(b) with Fig. 1(a), it can be seen that the annealing treatment promoted interface diffusion between the Ti layer and the diamond substrate significantly. The solid curves also showed that the concentration of oxygen in the TiC layer increased significantly after the sample was annealed. Oxygen resulted from the diffusion and reaction of residual oxygen with titanium in the high vacuum. The kinetic energy of O KLL in the sample was 509.5 eV, which can be attributed to TiO_2 species, indicating that TiO_2 species was embedded in the whole TiC layer.

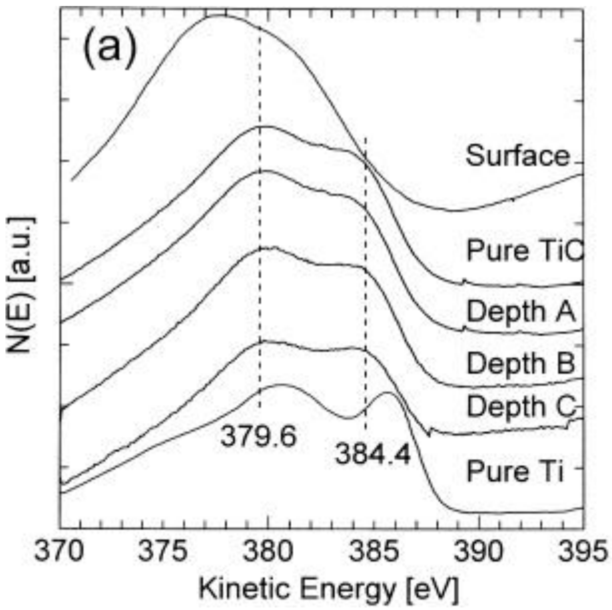

Figure 2. Auger line shapes of Ti LM1M4 and C KLL at various depths of a Ti layer/diamond sample: (a) Ti LM1M4 line shapes; (b) C KLL line shapes.

Figure 2(a) shows the Ti LM1M4 Auger line shapes at various depths of Ti/diamond sample. On the surface of the sample, the Ti LM1M4 spectrum consisted of a single peak resulting from Ti L3M1M4 Auger excitation. The kinetic energy was 377.5 eV and can be attributed to pure TiO_2 species.10 The Ti LM1M4 spectrum of pure Ti consisted of two peaks.

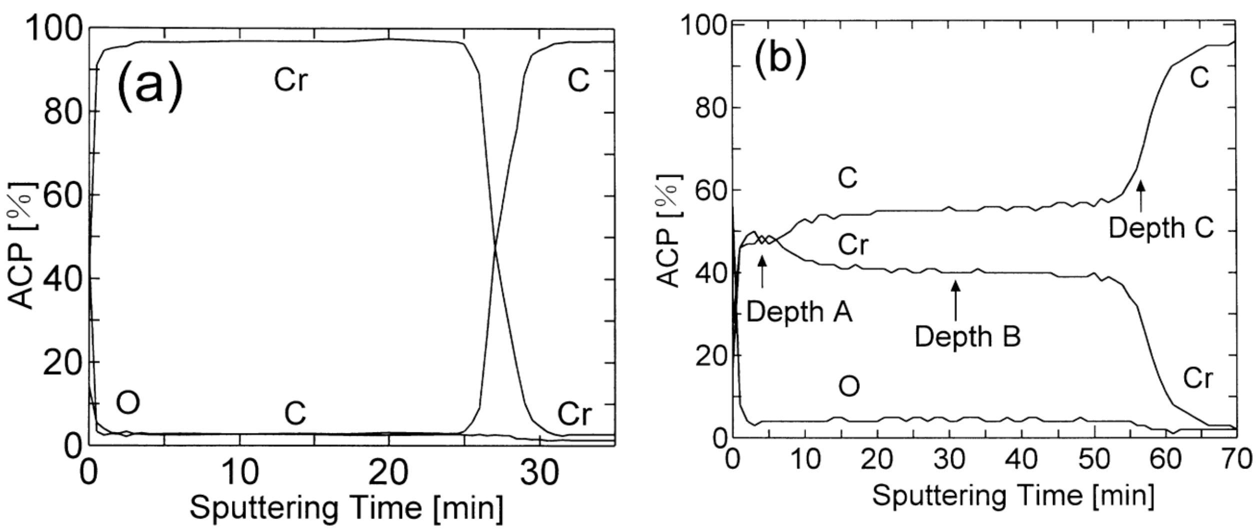

Figure 3. The depth profile spectra of a Cr layer/diamond sample before and after annealing in a high vacuum: (a) before annealing; (b) after annealing at 600 °C for 4 h.

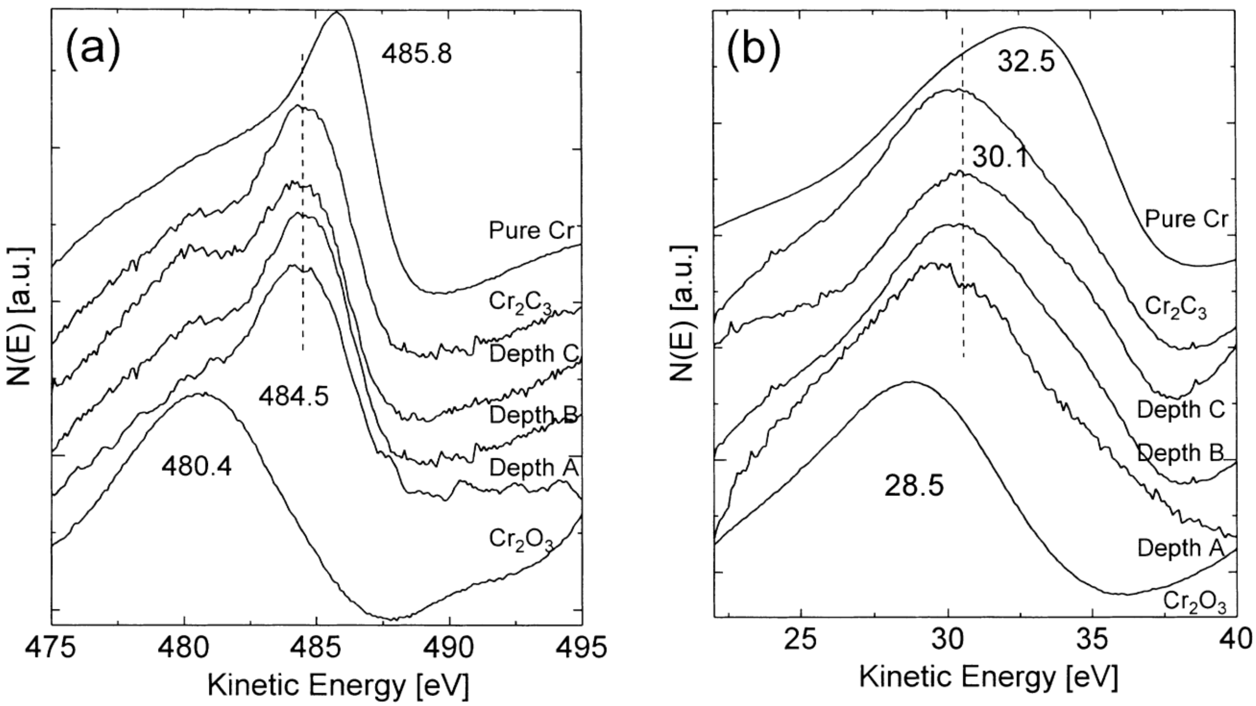

Figure 4. Auger line shapes of Cr LM1M4 and Cr MVV at various depths of a Cr layer/diamond sample: (a) Cr LM1M4 line shapes; (b) Cr MVV line shapes.

Figure 3(a) shows the AES depth profile spectrum of a Cr/diamond sample before annealing. The thickness of a Cr layer and an interface layer was _800 nm and 150 nm, respectively. The figure indicates that oxygen only existed on the surface of the Cr layer and almost did not diffuse into the Cr layer. The sputtering deposition did not cause strong interface diffusion on the interface of Cr/diamond. In addition, the line shapes of C KLL at depths A and B showed three characteristic peaks of metal carbide, indicating that the chromium carbide interlayer was formed during metallization of diamond. The above results suggested that the Cr layer reacted with diamond particles to form a Cr2C3 layer with an upper surface layer of CrC after annealing treatment.

The authors concluded that during the metallization of diamond, interface diffusion and a reaction between the metal layer and the diamond particles took place. A TiC surface layer formed for the Ti/diamond sample and a Cr2C3 interlayer with a CrC upper layer formed for the Cr/diamond sample. Auger electron spectroscopy line shape analysis revealed the chemical states of carbon, titanium and chromium during AES depth profile analysis.

<u>References</u>

1. Yongfa Zhu, *. W. (1999). Application of AES Line Shape Analysis for the Identification of Interface Species During the Metallization of Diamond Particles. *Surface Interface Analysis 28*, 254–257.

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