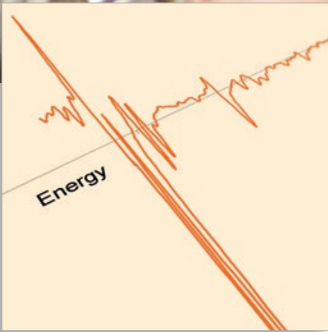

Scanning Auger Microscopy (SAM/AES)

- surface analysis
- concentration depth profiling
- 2D elemental map
- 0.5 - 5 nm information depth
- lateral resolution ≥ 40 nm
- solid materials

Scanning Auger Microscopy (SAM or Auger Electron Spectroscopy, AES) is an analytical technique that is used to determine the elemental composition of the top few nanometers of all kinds of solid, electrically conductive materials.

SAM takes place under ultra-high vacuum conditions, probing the surface of interest with a focused electron beam. Auger electron emission is initiated by the incident primary electrons that collide with inner shell electrons of atoms of the sample, leaving those atoms in an ionized state (step 1, fig. 1). Subsequently, the inner shell vacancy is filled by a higher energy level electron (step 2, fig. 1), creating an energy surplus, which can be used to emit a third electron, the so-called Auger electron (step 3, fig. 1). These emitted Auger electrons escape from the surface with a kinetic energy characteristic of the parent atom. The kinetic energy of the Auger electrons is analyzed, resulting in a spectrum that acts as a fingerprint of the elemental composition of the probed surface.
The information depth, which is limited by the mean free path of the Auger electrons traveling through the material, is typically in the order of 0.5 to 5 nm. In SAM all elements except H and He can be detected. Semi-quantitative values of atomic concentrations of the elements present at the surface can be obtained.

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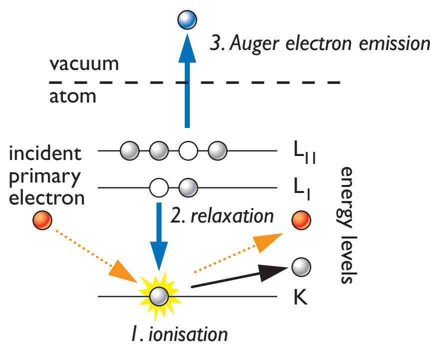


Fig. 1: Schematic diagram of the Auger process. In this example, the incident primary electron causes the ejection of a K-shell electron and finally the emission of an Auger electron.

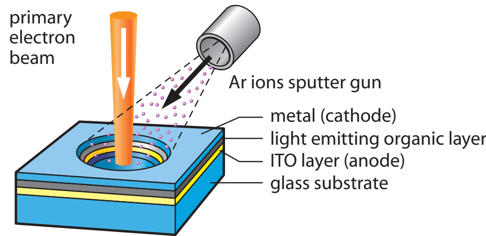


Fig. 2: Schematic diagram of the set up for compositional depth profiling of the layered structure of a pixel from an organic LED display.

As the focused electron beam can be scanned across the surface, scanning electron microscopy (SEM) images can be provided, which in combination with SAM analysis can give a lateral distribution of a particular element present on the surface with very high spatial resolution (40 nm). Compositional depth profiles through buried layers or interfaces can be obtained by combining SAM with ion beam sputter etching. In such a depth profile, the intensities of elements present at the exposed surface of the sample are monitored as a function of the sputter time. The sputter time can be converted to a depth scale when sputter rates of the analyzed materials are known.

A typical application: compositional depth profile of a pixel from an organic LED display

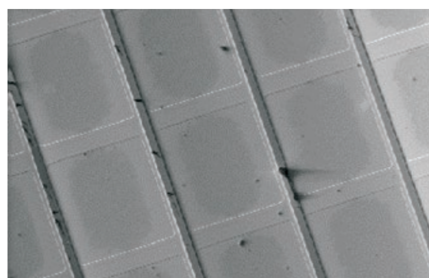
Organic light emitting diodes (LED) are devices that basically consist of a light emitting organic layer sandwiched between a cathode and an anode (fig. 2). Indium-tin-oxide (ITO) is typically used as a transparent anode, while a metal (e.g. Al) is used as the cathode. If a positive voltage is applied to the ITO (anode) and a negative voltage is applied to the metal cathode, a current can flow through the organic layer and light will be generated. The ITO layer is transparent and usually mounted on a glass substrate. This offers the possibility to use organic LED devices in displays.
Figure 3 shows a SEM image of part of a display that consists of an array of pixels.

Each of these pixels is an individual organic LED device. In order to find out the elemental depth composition of such an individual pixel, a SAM depth profile can be recorded by alternating sputtering with an Ar^+ beam and spectroscopic data gathering with an electron beam (fig. 2). The concentration depth profile measured for various elements is depicted in figure 4, showing the stack of layers. Note that the Al at the interface with the organic layer shows some oxidation.

Applications

- identification of surface contamination on wafers, wires, leadframes, cathodes
- cause of (local) de-lamination and bad adherence of layered structures
- determination of the composition of (multi)layer structures (e.g. oxidation and/or contamination of interfaces)
- characterization of the surface composition of powders and/or individual grains
- compositional analysis of (metal) grain boundaries

Fig. 3: SEM image of the pixel array of an organic LED display. Indicated in the center of one pixel is the area of analysis for the compositional depth profile.



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For more information:
Phone: +31 40 27 40455
E-mail: innovationlabs@philips.com
www.innovationlabs.philips.com

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Characteristics

Sample type
- solid materials (bulk, powders, multilayers etc.)

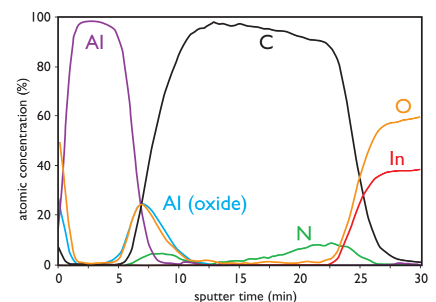
Sample size
- up to a maximum diameter of 60 mm

Information depth
- ranging from 0.5 - 5 nm; in combination with ion beam etching up to several μm

Lateral resolution
- 50 nm under SAM conditions and < 50 nm under SEM conditions

Detection limit
- 0.1 at% or 0.01 monolayer

Fig. 4: Compositional depth profile measured on a single pixel of an organic LED display.



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