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Auger Electron Spectroscopy (AES): A Versatile Microanalysis Technique in the Analyst's Toolbox

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In order to determine the usefulness of an analytical technique and to differentiate it from other technique options for a given application, several criteria are important. These criteria include spatial resolution (lateral vs. depth; imaging vs. elemental composition), sampling depth, detection limits and quantifiability of the data. A graphical comparison of many of the techniques that are at the analyst's disposal are shown in Figure 1. The role of Auger in this context will be discussed in detail.

Auger Electron Spectroscopy is a microanalysis technique used to examine the near-surface composition of a solid. It is based on the Auger process, in which an atom after ionization relaxes to a lower energy state by ejection of an Auger electron. The atomic species emitting the Auger electrons can be identified based on the kinetic energy of the Auger electrons and their concentrations can be calculated from measured peak intensities [1]. The use of a finely focused electron beam with a minimum beam diameter below 10nm allows for imaging and compositional analysis on very small scales.

As for other imaging techniques, the image resolution is primarily determined by the beam size. Currently the smallest beam size achievable in Auger instruments is around 3nm. This allows for imaging and mapping of elemental distributions at magnifications of 500kX and above. The high spatial resolution enables the analyst to characterize features only a few times larger than the beam size. It needs to be taken into consideration however that at such small scales, the surrounding area contributes to the spectrum due to beam scattering [2].

The ability of a technique to analyze a subsurface feature depends on the depth resolution. AES is a surface analysis technique with a near-surface depth resolution primarily determined by the attenuation length of the Auger electrons, which ranges from 0.3-5nm. Therefore, detection of very thin surface features is one of the strengths of AES. Larger depths can be accessed by depth profiling which involves removal of material with an ion beam. For shallow depths, the depth resolution is determined not only by the sampling depth but also by ion-solid interactions that occur during depth profiling. This type of profiling is routinely used for the characterization of thin surface layers such as the passivation layer on medical devices or stainless steel substrates. For larger profiling depths, sample roughening becomes the limiting factor but can often be mitigated by using Zalar rotation. An alternative approach to profiling is using cross-sectioning, either mechanically or with a Focused Ion Beam (FIB), to expose the feature of interest. In this case, the depth resolution is determined by beam size and backscattering.

Auger provides primarily elemental information; however, in some cases, a Linear Least Squares fit or Target Factor Analysis can be used to extract chemical information from the shape of the Auger peak [3]. Quantification is performed by utilizing either elemental relative sensitivity factors (RSFs), based on elemental standards [4] or average matrix RSFs [5], which account for some of the matrix effects. The highest accuracy can be achieved by measuring sensitivity factors on reference samples of known composition. Compositional analysis of submicron features can be very challenging since in most cases the signal contribution from the substrate cannot be eliminated.

Recent developments focus on the use of higher energy resolution and the integration of additional techniques such as EBSD, EDS and FIB. Combining different techniques in one instrument allows the analyst to obtain supplementary or complementary information in-situ, which increases the versatility and expands the applicability range of the technique.

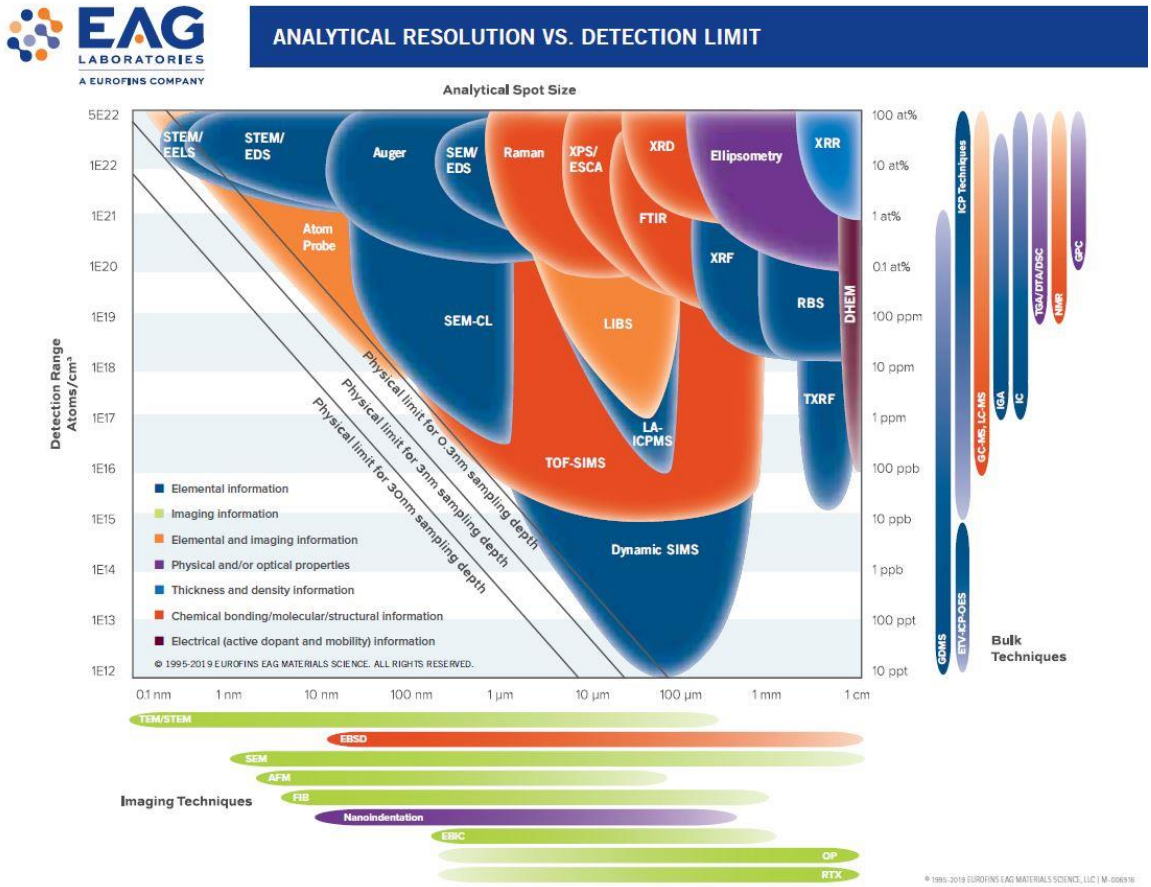

Figure 1. SMART Chart: Visual reference for comparing analytical techniques in terms of analytical spot size and detection range

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