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Auger Electron Spectroscopy – History and Applications in Materials Characterization with Emphasis on Medical Devices

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The field of surface science has expanded significantly with advances in high resolution imaging applied to a wide range of materials from medical devices to nanotechnology [1]. Though these high resolution imaging techniques help one visualize grain boundaries and nano-structures, it is essential to understand the chemical nature of these materials at the surface and in bulk. The functional properties of many materials are significantly affected by surface modifications in the first few nanometers. Conventional characterization techniques, such as Energy Dispersive X-ray Spectroscopy (EDS) associated with many high resolution imaging systems Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM), are not capable of easily detecting these surface modifications. This is due to the penetration depth of the electron beam and excitation volume in the material and the corresponding emitted X-rays from this volume. This volume varies significantly based on the material. Modern state of the art scanning Auger Electron Spectroscopy (AES) systems compliment these high resolution imaging techniques and provide valuable elemental and chemical characterization for these near surface structures with a spatial resolution better than 10 nm and a depth resolution of a few nm. Figure 1 is an example of high resolution SEM and Auger maps for Fe, O, Mn, C and B highlighting elemental surface segregation of a few nm.

The surface chemistry of medical devices (figure 2: is an example of a stent) is critically important to their overall performance since not only must biocompatibility be assured but several key performance characteristics are governed by the chemistry of the surface and near surface region [2]. For metallic components, ultra-thin surface passivation and nitridation are often important parameters for device performance. Understanding surface functionality, possible degradation by leaching, corrosion or flaking of these ultra-thin layers, as well as distribution of these various species in the z-plane can all be critical to optimize the performance of these components. Figure 3 is an Auger depth profile of a nickel rich alloy with a thin surface passivation oxide layer. Identifying micro and nano-contaminants at grain boundaries and/or discolorations are important.

In this talk we will highlight the unique analytical capabilities of scanning AES in the areas of metallurgy, semiconductors and its usefulness in medical devices characterization. We will also perform an in-depth comparison between AES and SEM/EDS emphasizing the strengths of each in order to help the material scientists determine when and where each technique should be used.

References:
[1] S. N. Raman et al. (2011) Microscopy today Volume 19, Issue 2, March 2011, pp. 12-15, https://doi.org/10.1017/S1551929511000083
[2] S. Nagaraja et al. Shap. Mem. Superelasticity (2015) 1: 319–327

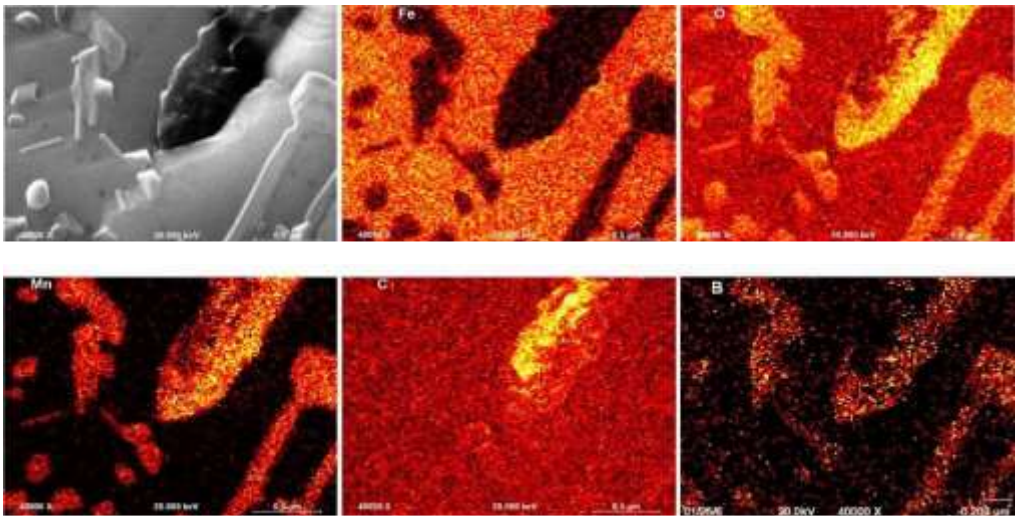


Figure 1: High resolution SEM and Auger maps for Fe, O, Mn, C and B highlighting surface segregation

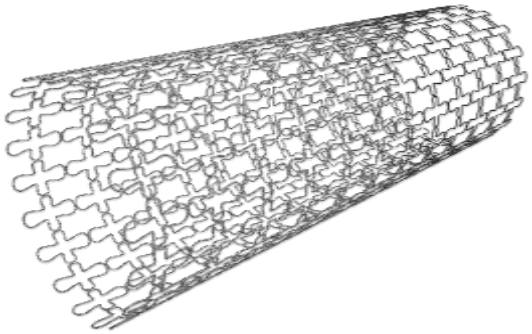
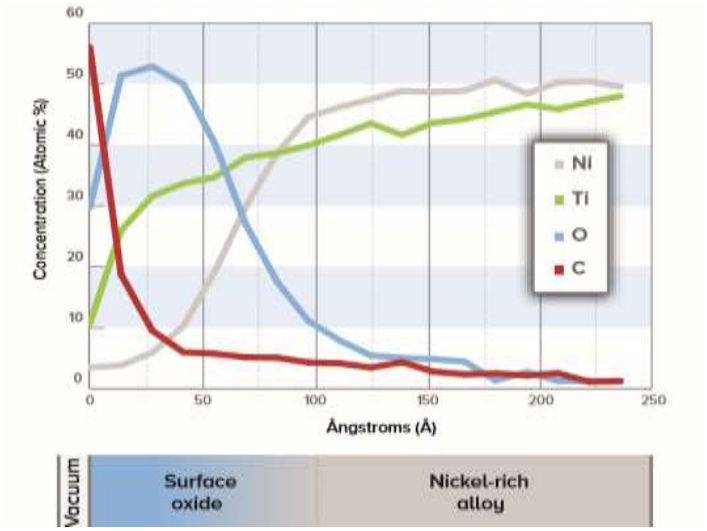


Figure 2: A typical stent

Figure 3: Depth profile of nickel rich alloy with surface oxide layer



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