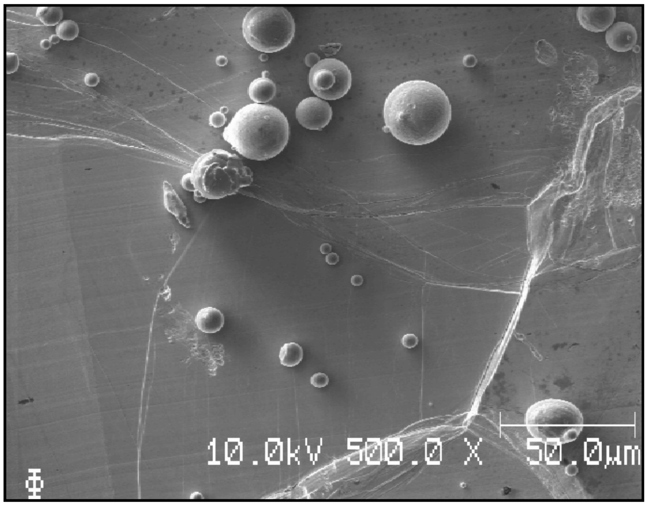
High Spatial Resolution Auger Imaging of Highly Topographic Samples

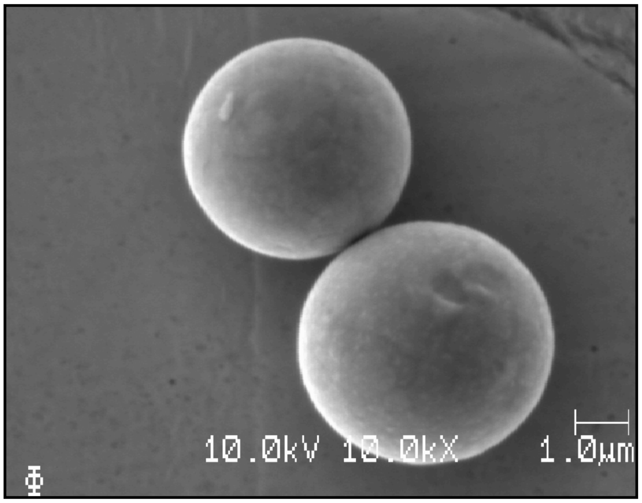
Introduction

Commercial Auger Electron Spectroscopy (AES) instruments have continually evolved for more than 25 years. The most noticeable improvements have been in spatial resolution and instrumental sensitivity. In today's market, nearly all instruments utilize Schottky field emission sources to produce high brightness electron beams for high spatial resolution imaging and analysis, as well as some form of multi-channel detection for high elemental sensitivity. Only PHI Scanning Auger Nanoprobes utilize a Cylindrical Mirror Analyzer (CMA) with a coaxial electron gun to allow unambiguous analysis of topographical samples. For this discussion, we will assume that topographical samples are those with topographies other than flat. High spatial resolution AES analysis can include secondary electron imaging of sample surfaces, analysis at selected points or areas, and acquisition of Auger elemental images, line scans and depth profiles. This publication will demonstrate the ability of PHI scanning Auger nanoprobes to provide Auger elemental images and line scans from highly topographic surfaces.



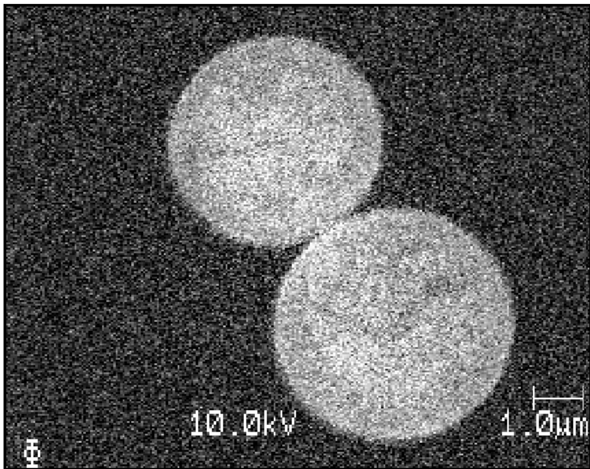
500 X secondary electron image

Most samples requiring AES analysis are topographic in nature, especially when examined at high magnification. Almost nothing is flat at 10,000 X. A major advantage of the coaxial CMA for AES analysis is that Auger signal detection is fully symmetric and uniform about the axis of the electron beam used to image and analyze the sample. Essentially everything imaged by the primary electron beam can be analyzed. There is no preferred direction for Auger analysis (and therefore no deleterious shadowing of surface features from the analyzer). For this discussion, a sample consisting of a fine dispersion of spherical Ni alloy particles was gently pressed into a flat, soft In metal foil.



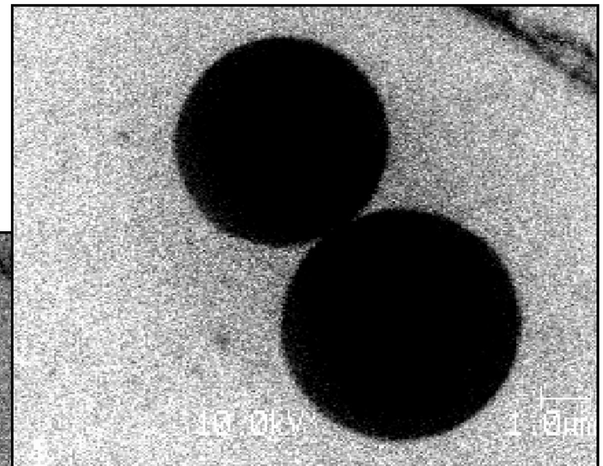
10 kX secondary electron image

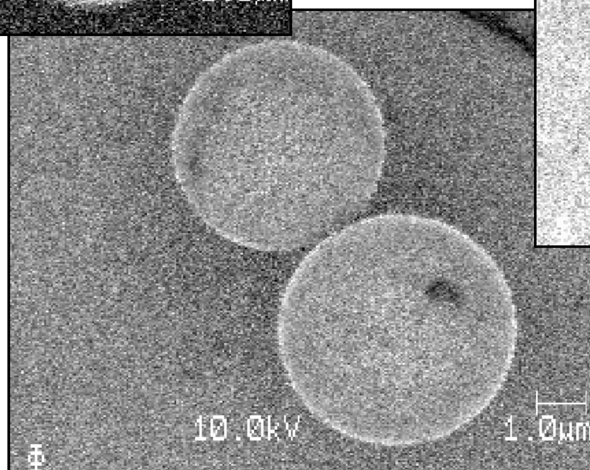
Secondary electron images, at magnifications of 500 X and 10 kX, show these highly topographic particles and the relatively flat substrate. The two Ni spheres selected for analysis are in contact with one another and are both less than 5 µm in diameter. Selected area analysis detected the two expected metallic species as well as C and O on the surface of both the Ni sphere and the In substrate. The Auger images, displayed in gray scale, were collected for all four elements at 10 kX magnification with a 256 x 256 pixel density.



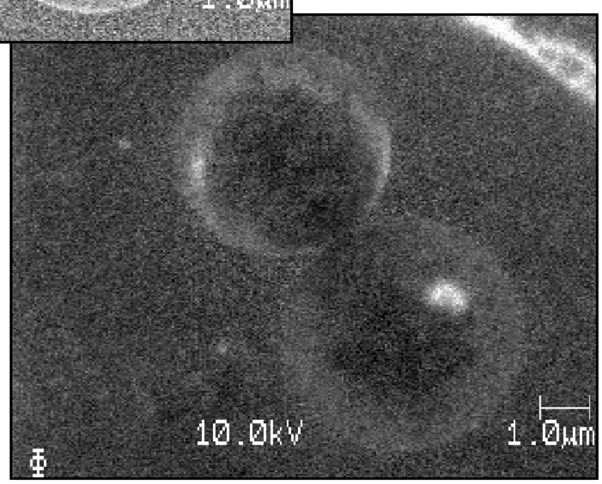
Ni Auger Image

In Auger Image





O Auger Image

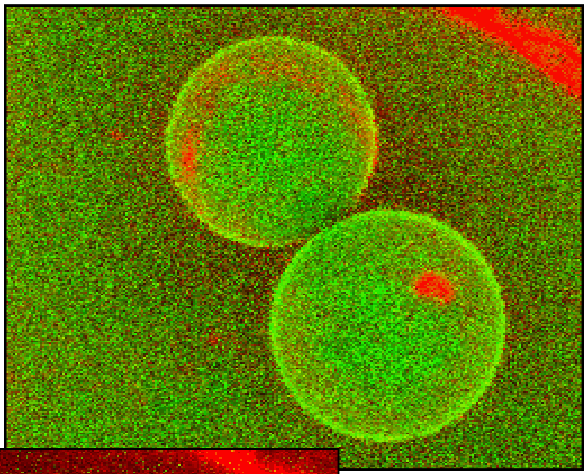


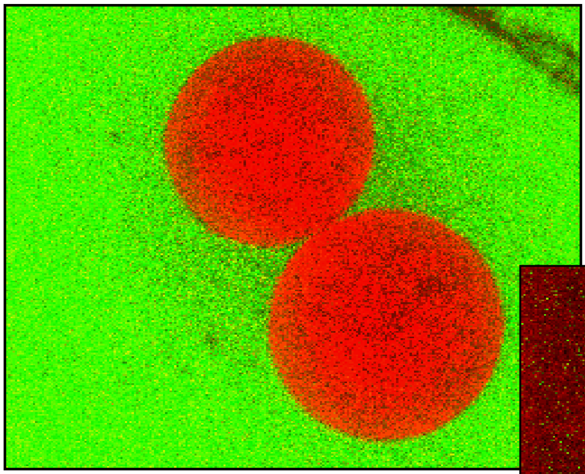
C Auger Image

The Ni Auger image shows a nearly uniform intensity over the surface of the sphere, even though the incidence angle of the electron beam changes from normal at the center of the sphere to grazing at the edge of the sphere. The In Auger image shows excellent uniformity, even at the submicron spacings where the spheres are nearly in contact with one another. An area in the upper right corner of the In image has a lower than average In signal intensity.

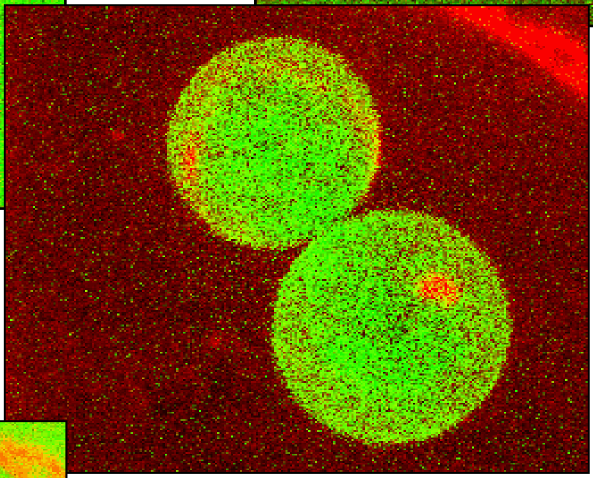
The O Auger images indicate a fairly uniform coverage with a few localized areas showing O depletion, including the same area that shows low In concentration. The C Auger image has high intensity areas that fill in the corresponding low intensity areas in the O and In maps. Color overlay Auger images clearly show the complementary nature of these images and the lack of shadowing.

10 kX color overlay of Auger Images:
Red = C, Green = O

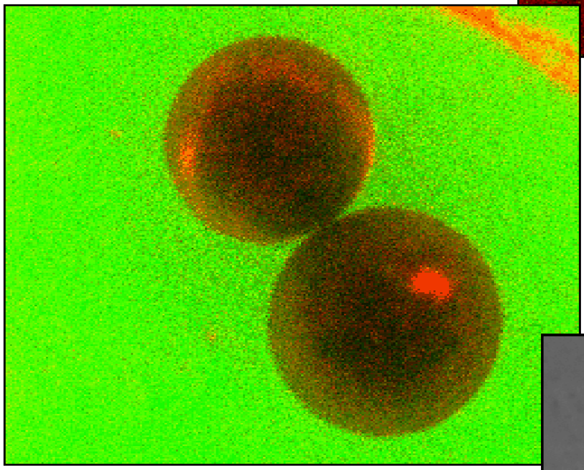




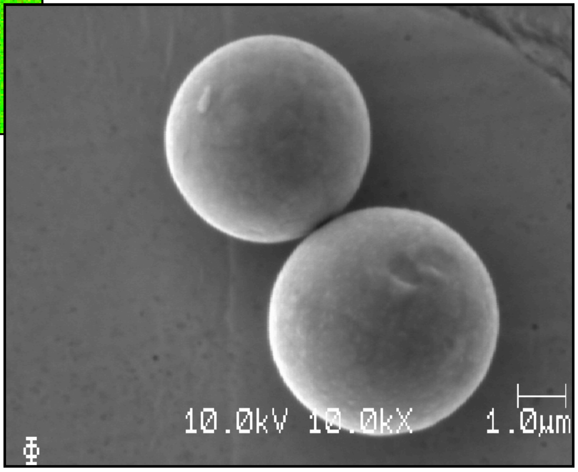
10 kX color overlay of Auger Images:
Red = Ni, Green = In



10 kX color overlay of Auger Images:
Red = C, Green = Ni

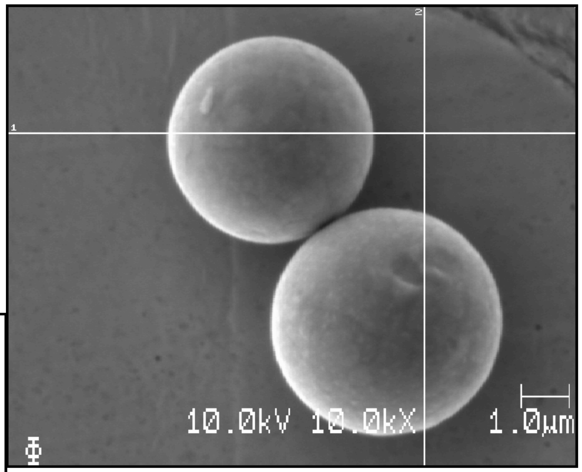


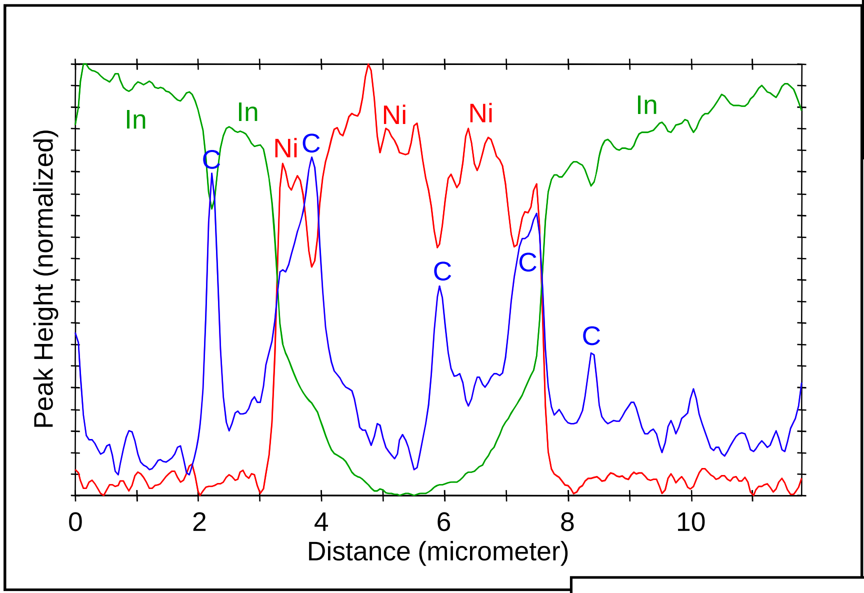
10 kX color overlay of Auger Images:
Red = C, Green = In



10 kX secondary electron image

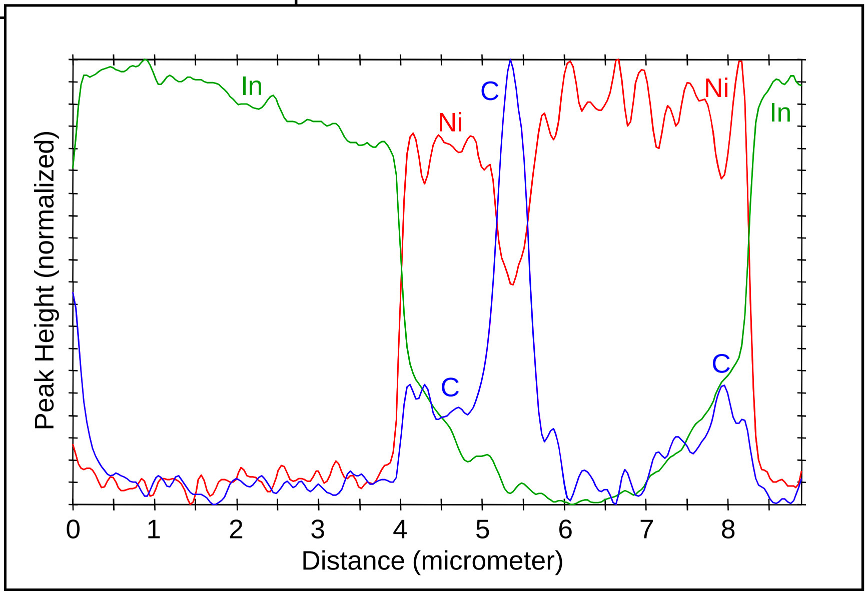
One horizontal and one vertical Auger line scan were collected at the positions shown. Line scans provide a more quantitative method of obtaining surface elemental distributions. Note that as the intensity of one elemental signal decreases, the intensity of the other increases.





Horizontal Auger line scan

The results shown are obtainable only with the PHI coaxial CMA approach, which enables the user to select analysis areas, to collect Auger elemental images and line scans, and to easily interpret data free from topographic influence.



Vertical Auger line scan

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