

Absolute Calibration of Auger Spectrometer for Measuring SE and BSE Yield

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Secondary electron (SE) yield δ and backscattered electron (BSE) yield η are the ratio of numbers of SEs (with kinetic energies $<50\text{eV}$) and BSEs (with kinetic energies $>50\text{eV}$) to the total number of incident electrons bombarding a solid, respectively. These two yields are key parameters for describing electron-solid interactions and are important for the interpretation of data from the scanning electron microscope (SEM) and Auger electron spectrometer (AES). Work to collect yield data has been in progress since the beginning of last century, and data reported by more than 100 authors has been tabulated in a database [1]. But the values in the database are disappointingly scattered, especially for the SE yield. An equally frustrating fact is that most collections of data cover only a limited number of elements, and few measurements have been done on compounds. Many conjectures have been made on the variation of material properties such as peak SE yield δ^m , corresponding beam energy E_{PE}^m , SE excitation energy ε and average attenuation length λ with atomic number [2]. To verify these conjectures, to test quantitative models of electron-solid interaction, and to make predictions on the yields of SE and BSE from binary compound ($A_xB_{[1-x]}$), we need a systematic and accurate method to collect δ and η data under uniform and reproducible conditions.

SE and BSE yield data are typically collected by measuring beam current and specimen currents with the sample grounded and at +50V bias or by using a simple retarding field analyzer. Both of these methods have significant problems and inherent errors. A preferable method for SE and BSE yield measurement is through the analysis of complete emitted electron spectra collected on an AES, in which the SE and BSE can be separated and analyzed. An example of a spectrum recorded using a cylindrical mirror analyzer (CMA), a typical spectrometer type used in Auger instrumentation, is displayed in Fig. 1. One advantage of this method is that the specimen surface can be sputtered in situ by an ion gun and kept clean under ultra high vacuum (UHV). The specimen composition can also be analyzed simultaneously using the Auger peaks. The hidden problem with this method is that the transmission and detection efficiency of an AES is a continuously varying function (response function $Q(E)$) of the electron energy [3]. In order to obtain the “true” spectrum, corrections for these efficiencies must be identified, measured or computed, and applied to the raw data.

The response function $Q(E)$, of a typical CMA-typed electron spectrometer has a shape similar to the one shown in Fig 2(a) and produces a spectrum much different from the “true” one, shown in Fig 2.(b). A tremendous amount of work has been done on absolute AES intensity calibration. However, most of this effort has focused on the SE and BSE background subtraction and Auger peak profile correction, not on the absolute intensity for the whole spectrum, especially for the low SE energy range [3-4]. Current AES intensity calibration software of the National Physical Laboratory (NPL) and Surface Analysis Society of Japan (SASJ) are designed to calculate $Q(E)$ of an instrument using $Q(E)=N(E)/n(E)$, where $N(E)$ are the intensities of the spectra for reference materials (typically, Cu, Ag and Au) collected on the instrument of interest and $n(E)$ are the “true” intensities for the same material precisely measured by NPL and SASJ and used as the ultimate reference in the software [3-

4]. This method is reasonable for its purpose but the SE and BSE yield values calculated from the calibrated spectra are incomplete or unsatisfactory. Further advancement on calculating or measuring the response function for an Auger spectrometer equipped with a CMA is still needed.

References

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- [5] The advice and help from Dr. M. El-Gomati (UY in UK), Dr. P. J. Cumpson (NPL in UK), Dr. S. Tanuma (NIMS in Japan), and Dr. C. J. Powell (NIST in USA) are gratefully acknowledged. The research was carried out at ORNL, managed by UT-Battelle, LLC, for the U.S. Department of Energy under contract No. DE-AC05_00OR22725.

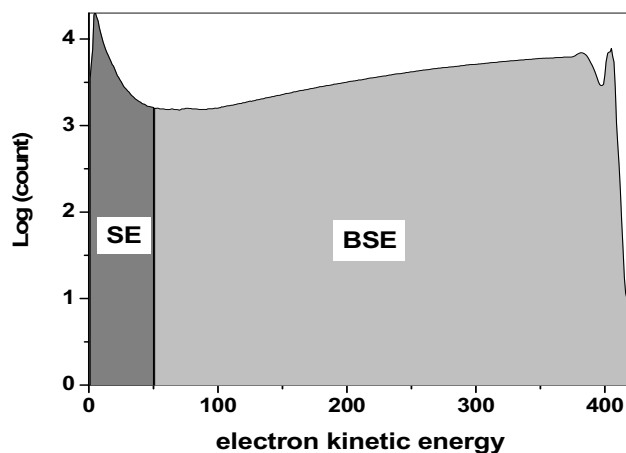


FIG. 1. Total spectrum of emitted electrons with energies from 1eV to the incident energy collected on an AES. Areas in different gray scale represent total SE (<50eV) and BSE (>50eV).

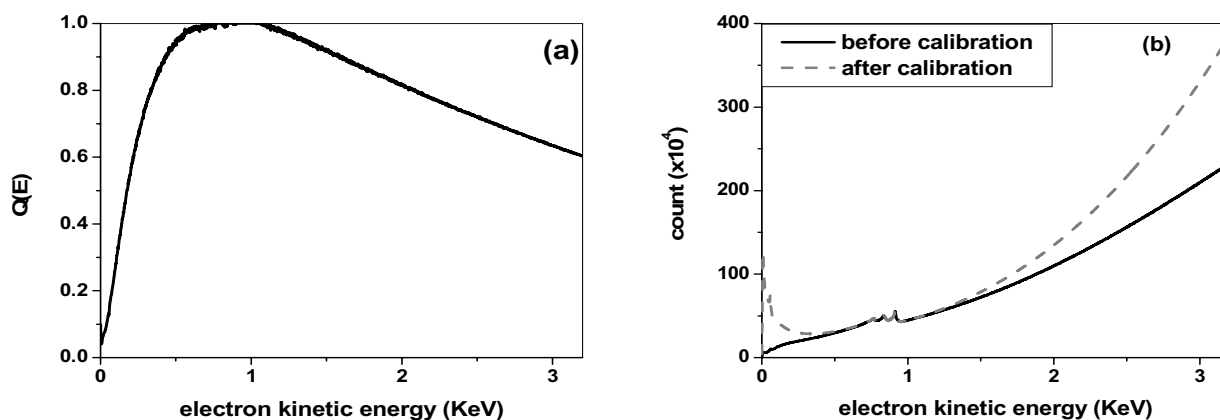


FIG. 2. (a) Characteristic experimental response function $Q(E)$ for an AES machine. (b) As received spectrum collected on an AES machine and the one after calibration.