Parallel Auger Electron Analysis inside Scanning Electron Microscopes

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In the fabrication and failure analysis of integrated circuits, the Scanning Electron Microscope (SEM) is an indispensable inspection tool. Recently, a wide-band parallel energy spectrometer was used together with an Argon flood gun to demonstrate that Auger Electron Spectrometry (AES) can be carried out at relatively high pressures (< 10-6 Torr), comparable to the kind of pressures inside the chambers of SEMs[1]. The Argon flood gun first cleans the specimen surface, and then AES must be carried out within a few seconds, longer data-acquisition times are not possible due to the rapid buildup of hydrocarbons on the specimen surface after the flood gun is switched off. It is for this reason that a parallel energy spectrometer is used, as opposed to a conventional sequential one, speeding up data-acquisition time that would ordinarily take several minutes. This method offers the possibility of overlaying valuable material analysis information on to the SEM inspection image.

This paper presents developments of a high performance parallel energy spectrometer that can be used inside SEM chambers as an add-on attachment. The spectrometer is based upon the electric field Parallel Radial Mirror Analyzer (PRMA) design[2], which is predicted to have over two orders of magnitude better signal-to-noise characteristics than previous wide-band parallel electron energy spectrometers. This is made possible through its superior focusing action (second-order) and inherent rotationally symmetric geometry. This paper will present further developments in the PRMA design and preliminary experimental results.

Figure 1 shows simulated direct ray tracing of 100 to 2500 eV electrons. Figure 2 shows a comparison of the PRMA's simulated energy resolution compared to the previous Hyperbolic Field Analyzer (HFA) design.

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[1] D. Cubric, A. De Fanis, I. Konishi, S. Kumashiro, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated **645** (2011).

[2] A. Khursheed, H. Q. Hoang, and A. Srinivasan. Journal of Electron Spectroscopy and Related Phenomena **184** (2012).

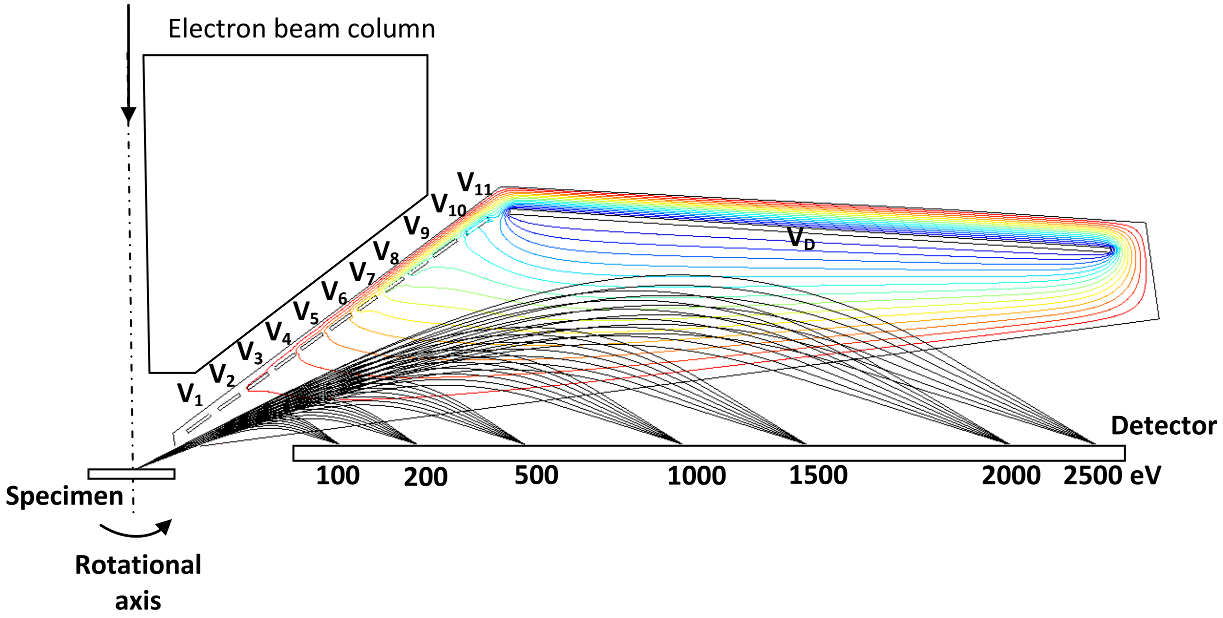

Figure 1: Simulated trajectory paths through an improved second-order focusing PRMA design. Equipotential lines plot from -45.8 to -687.5V in uniform steps of -45.8V are also indicated. The electrode voltages V_1 to V_{11} and V_D are: -3.292V, -22.417V, -53.750V, -83.333V, -125V, -179.208V, -241.667V, -325V, -375V, -395.833V, -458.333V and -687.5V.

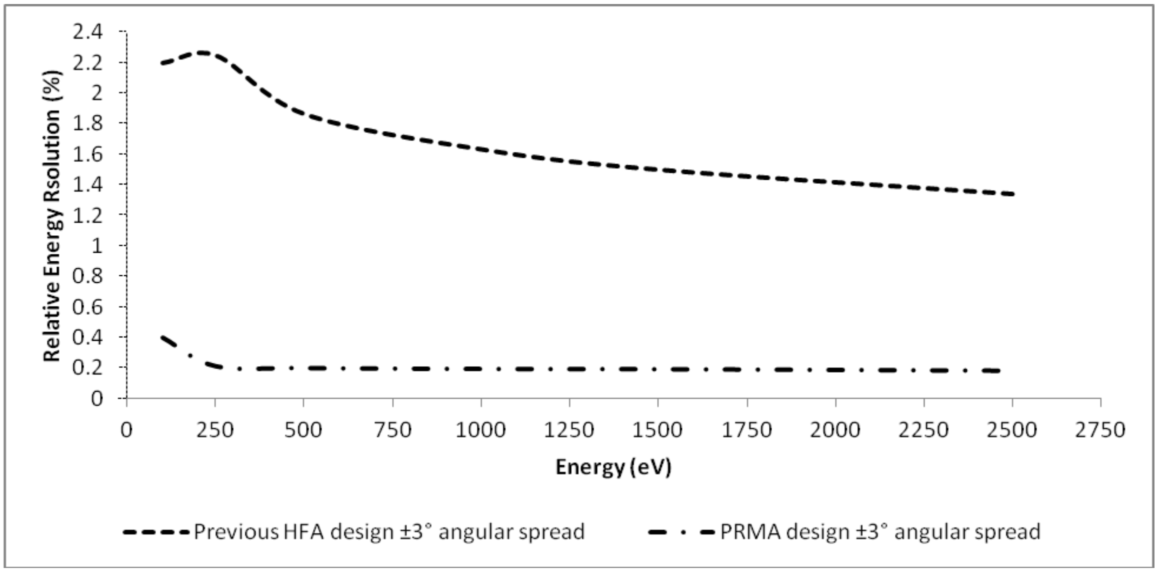

Figure 2: Comparison of the PRMA's simulated energy resolution to the previous Hyperbolic Field Analyzer (HFA) design for ±3° angular spread in both cases.