Electron Beam Postionization of Sputtered Neutrals

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1. Introduction

Historically, electron beam postionization of sputtered neutrals, using the ionizer of a gas phase mass spectrometer /1/, was the first way to sputtered neutral mass spectrometry (SNMS). It was revived and further developed in recent years by several groups /2-5/ after Oechsner and his coworkers demonstrated the prospects /6-9/ of SNMS as a tool of quantitative mass spectrometric thin film and bulk analysis of solids.

With respect to SIMS, the advantage of SNMS is clearly the limited role of matrix dependence of secondary ion yields: A variation of the ionization probability of a sputtered species, e.g. from $10^{-5}$ to 0.5, introduces a variation of SIMS sensitivities of nearly five decades, but a factor of two only in SNMS calibration by complementarity.

With respect to Auger and photoelectron spectroscopy it offers the advantage of overcoming preferential sputtering as an artefact disabling quantitative calibration of concentrations in sputter depth profiling. In addition even the worst implementations of SNMS exceed the sensitivity of electron spectroscopy. To make this advantage real and to control the possible trade-offs of SNMS implementations one has to look at the physical problem of sputtered particle postionization. This is illustrated in Fig. 1, /5/ showing schematically the energy distribution of various radiations resulting from ion bombardment of solid surfaces and in addition that of residual gas: In a SIMS instrument the task is to collect secondary ions as efficiently as possible and at the same time to suppress all other radiations to result in a good dynamic range.

In SNMS the principal problems are the same, but in addition one needs efficient postionization along with suppression of the secondary ion signal, which would destroy quantitation, and suppression of the residual gas signal, which would limit the dynamic range by mass interference. Both suppression ratios must be $10^{-6}$ or smaller for "pure" SNMS spectra.

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2. Experimental

Figure 2 shows a schematic of our most recent electron beam impa SNMS instrument /11/. It is an improvement of our first desig /5, 10/. With respect to the secondary ion and residual gas sign suppression schemes it differs from other approaches /2-4/ electron beam impact postionization.

Fig. 2 Schematic of a quadrupole-based SIMS/SNMS/RGA instrument with electron beam impact post-ionization and energy filtering /11/.