

A NOVEL HIGH RESOLUTION TUNABLE X-RAY FLUORESCENCE IMAGING SPECTROMETER FOR MATERIALS ANALYSIS

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Abstract: X-ray fluorescence (XRF) micro-analysis is a very widely used technique in fields as diverse as materials science, forensic science and semiconductor manufacturing, to name a few. This technique, using either x-ray or electron beam excitation, allows for rapid determination of elemental composition with parts per million sensitivity. In characterization of thin films in semiconductor manufacturing, this technique can be used to determine the thicknesses of films with sub nanometer accuracy. Fluorescence maps can be obtained by either scanning the sample when x-ray probes are used or by the raster scanning a finely focused electron beam in a Scanning Electron Microscope and using energy dispersive spectrometers (EDS) and wavelength dispersive spectrometers (WDS). For x-ray microprobes, the spatial resolution is many microns and for electron microprobes it is normally on the order of a micron. With electron beams, higher spatial resolution can be obtained by shrinking the electron interaction volume by using a finely focused electron beam of low energy or perform analysis on very thin specimens (on the order of 100nm), which is of very limited practical use outside the field of basic research. These restrictions on spatial resolution can be removed by the use of Fresnel zone plates as an imaging optic and the ability to use the zone plate to image multiple elements one at a time forms the basis of a tunable x-ray fluorescence imaging spectrometer which allows for elemental identification capabilities of a spectrometer and very high spatial resolution (~ 50nm) limited only by the width of the outermost zone of the Fresnel zone plate. The size of the probe determines the field of view and interestingly also determines the energy resolution of the spectrometer and sub 100eV resolution can be easily achieved. The uses of this imaging spectrometer are many. For example, such a system can be used in semiconductor failure analysis such as imaging voids, shorts in copper or aluminum interconnects, elemental distribution in alloys, small particle analysis etc. High energy resolution of the spectrometer enables one to clearly image individual elements in the sample that neighbor each other in the periodic table such as Al/Si and Ni/Cu.

The fluorescence imaging spectrometer described in this paper is operated on a JEOL 8600A electron microprobe, optimized to image with soft x-rays in the 250eV-2500eV regime. The description of the instrument and its capabilities are described in detail elsewhere [1]. Sub 50nm resolution has been achieved. Various samples such as copper chips, aluminum chips, alloy samples and mineralogical samples have been imaged. The details of the experiments and the results obtained will be presented.

References:

- [1] M. Feser et al., Proc. 31st Int. Symposium for Testing and Failure Analysis (ISTFA) (2005) 158
- [2] This material is based upon work supported by the National Science Foundation under SBIR grant No. DMI-0512910.