ÁPlasma Analysis
Application Note 271-1

EQP
Energetic (Fast) Neutral Species Analysis

Summary

In many plasma processing applications the surface of the target work piece is bombarded by energetic neutral species as well as by energetic ions. The energy distributions of the bombarding ions have been studied for a number of years and the distributions have been correlated with measured properties of the bombarded surfaces. It is of interest to undertake similar studies for the case of bombardment by energetic neutral species, but there are very few published reports of such studies, particularly for experiments in which the energy distributions of the bombarding neutral species have been directly measured. The lack of published data is a consequence of the difficulty normally encountered in sampling the energetic neutrals, mass identifying them and measuring their energy distributions. The present application note reports the results of an investigation in which the energy distribution of neutral species from a target surface have been measured using the Hiden PSM plasma mass/energy analyser. The investigation used a copper source to generate the fast neutrals.

Manufactured in England by:

HIDEN ANALYTICAL LTD
420 Europa Boulevard, Warrington, WA5 7UN, England
t: +44 (0) 1925 445225 f: +44 (0) 1925 416518
e: info@hiden.co.uk w: www.HidenAnalytical.com

Experiment

The energies of energetic copper produced in a DC magnetron discharge were measured using a 300 amu Hiden PSM instrument. The magnetron discharge was operated using argon as the working gas at a pressure of around 1mTorr and a discharge power of around 10 watts. The cathode of the magnetron was a 2" diameter copper disc which was positioned 5cm from the grounded entrance plate of the EQS instrument. The latter contained a 500um sampling orifice through which positive ions, neutral atoms and photons could enter the ionisation source of the PSM instrument. For the present measurements on neutral species, any ions passing through the sampling orifice were rejected before reaching the PSM's ionisation source by applying suitable potentials to two grid electrodes placed between the orifice and the ionisation source. It was not possible to prevent a small number of photons from the magnetron discharge from entering the ionisation source. The consequences of this are discussed below. The ionisation source of the PSM was a so-called 'sealed' source, by which we mean that any neutral gas entering the PSM through the entrance orifice passed directly into the ionisation source before being pumped by the PSM's pumping system. There was no pumping route from the orifice which by-passed the ionisation source.

The experimental measurements made were for the following conditions:

a) Measurements of the energy distributions of copper ions reaching the detector of the PSM instrument with the plasma operating and the filament of the PSM's source switched on

b) Measurements as in a) with the plasma on but the PSM's filament turned off

c) Measurements of the energy distributions of the (few) copper ions reaching the detector when the plasma was turned off but the PSM's filament was operating.

Although the entrance of the PSM could be biased to prevent almost all ions and electrons from the magnetron from entering the PSM and eventually reaching the PSM's detector, a small number of copper ions may have done so. In addition, small numbers of ions were produced in the PSM source by photons generated in the plasma and entering through the PSM's sampling orifice. The combined signals from these sources gave a background signal shown in Figure 1.

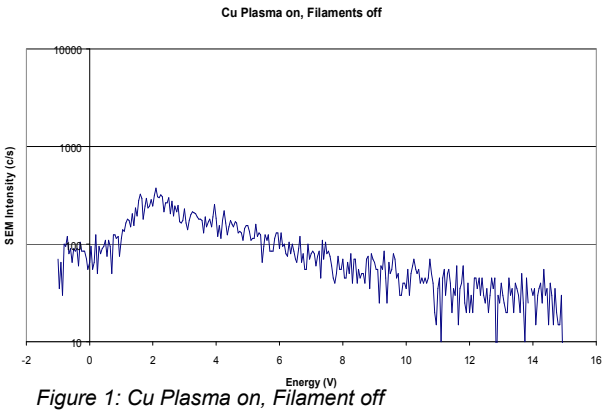

Figure 1: Cu Plasma on, Filament off

With the PSM's filament turned on the total ion signal recorded was as shown in Figure 2.

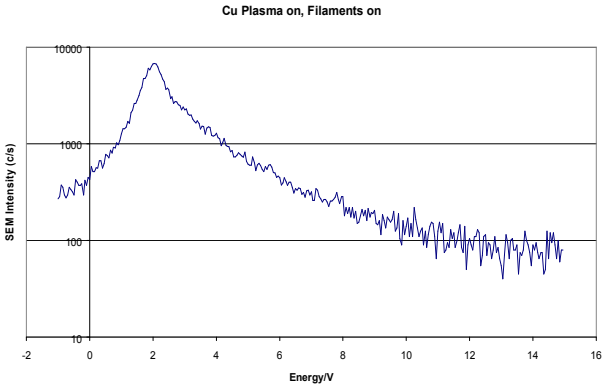

Figure 2: Cu Plasma on, Filament on

By subtracting the background signal of Figure 1 from the data of Figure 2, the true energy distribution of the ions generated in the PSM's source from energetic neutrals entering from the magnetron plasma is as shown in

Figure 3.

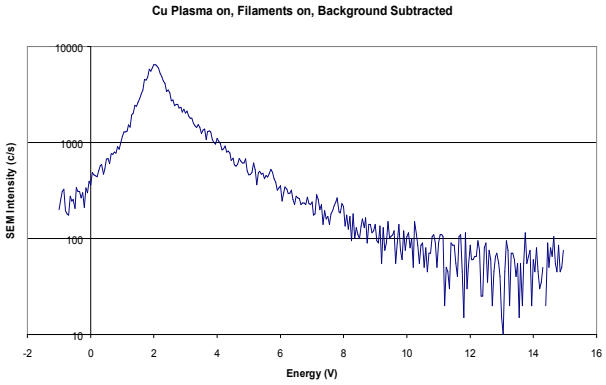

Figure 3: Cu Plasma signal, Background subtracted

It should be borne in mind that from the energies shown in Figure 3, some neutrals energy of 1.5eV was due to the potential applied to the cage of the PSM's ionisation source. The range of energies of the neutral atoms from the magnetron cathode extended to just over 8eV.

The energy distribution shown in Figure 3 may be compared with that of the (small) number of copper ions generated in the PSM's source when the plasma was turned off, probably by ionisation of the small number of copper atoms evaporated from the surfaces of the source, which had been deposited there earlier in the experiment.

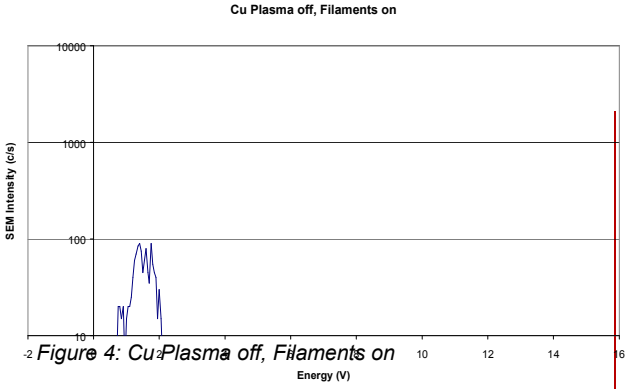

Figure 4: Cu Plasma off, Filaments on

Figure 4 shows that these ions, as expected, have an energy range of about 2eV, centred at approximately 1.5eV. The difference between the distributions of Figure 3 and 4 is consistent with the interpretation of the high energy range of Figure 3 as being due to the ejection of energetic copper atoms from the magnetron's cathode.