The ALCHIMIA project

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I. INTRODUCTION

The ALCHIMIA project (Analysis of Luminescence and Charge collection induced by Micro Ion beAms) is aimed to characterise opto-electronic properties of semiconductor and insulator materials and devices by means of micro ion beam analytical techniques. The measurements was performed at the microbeam facility of the AN2000 accelerator using He and H ion microbeams with energies around 2 MeV. The research activity has been carried out in collaboration with the SELT project described elsewhere in this LNL-Report.

Two techniques have been developed: IBICC (Ion Beam Induced Charge Collection) and IL (Ion Luminescence). They have been applied to characterise advanced materials as natural and synthetic diamond [1,2,3], CdTe x-ray detectors [4], Si power diodes [5], GaAs Schottky diodes [6,7], cubic boron nitride powders [8]. Combined PIXE and IL measurements have also been performed to analyse marbles and natural silica glasses within the GEO-FI experiment.

II. EXPERIMENTAL SET-UP

A new IL system has been installed into the analysis chamber of the microbeam facility. It consists of a paraboloidal mirror located in front of the sample with a hole (∅=2 mm) to allow the microbeam to scan over the sample surface. The luminescence induced by ions is collected by the mirror and focussed at the entrance slit of a OXFORD MonoCL2 monochromator with a spectral range of 350-1200 nm, and spectral resolution less than 0.5 nm. The light intensity is measured by a HAMAMATSU 374 photomultiplier. The system can be simply connected to the microbeam acquisition system to get chromatic luminescence maps.

IBICC technique has been optimise by using a low noise charge sensitive preamplifier AMPTEK A250 directly connected to the sample to be analysed into the analysis chamber. Moreover, combined measurements of IBICC and IL have been carried out by using the panchromatic light collection set up developed during the SELT experiment [1,9].

III. ION BEAM INDUCED CHARGE COLLECTION

In this section we shortly summarise some recent results obtained by using the new IL system and still not published.

They concern the characterisation by IL of diamond tips fabricated by the group of Torino and used as x-ray microdosimeters [3]. These micro-dosimeters are 10-15 µm thick diamond film covering the top surface of a tungsten tip shaped by an electrochemical etching method normally used to make tip probes in

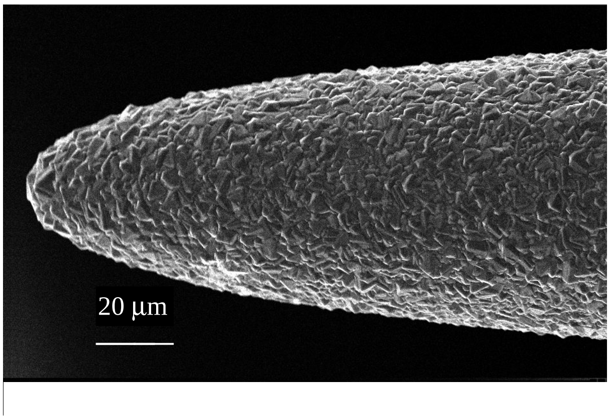

Fig.1 SEM image of a diamond tip.

scanning tunnelling microscopes. The diameter of the base of such tungsten tip is 200 or 300 micrometer. Fig.1 shows a SEM image of such a sample.

The diamond film acts as a solid state ionisation chamber where one electrode is the tungsten substrate and the counter electrode is a thin Ti/Au layer deposited on diamond.

Micro-IBICC technique is probably the unique tool suitable to investigate the electrical characteristic of such a device. Fig. 1

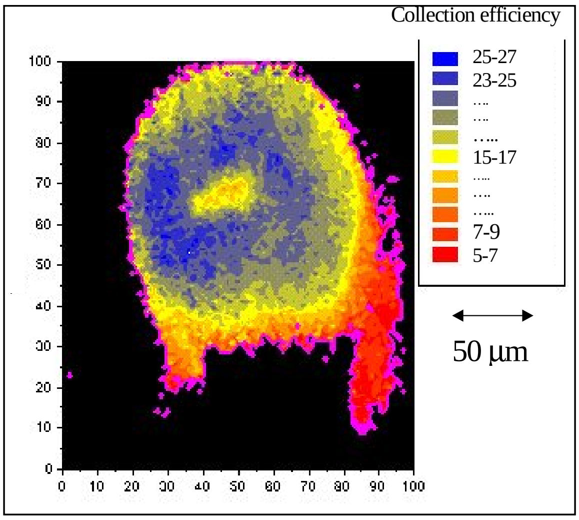

Fig .2 : IBICC map of a diamond tip. The diameter of the W substrate is 200 µm, the bias voltage is 240 V. The diamond film is about 15 µm thick.

shows the IBICC map of a diamond tip. The colour scale is shown on the right in term of charge collection efficiencies. The applied bias voltage is 240 V. The map has been obtained by using 2 MeV protons with a beam spot less than 5 micrometer in diameter.

The high charge collection occurs in regions around the top of the diamond tip where the efficiency is higher than 25%. The signals producing the two elongated smears at the bottom of the map are due to protons scattered by bonding wires.

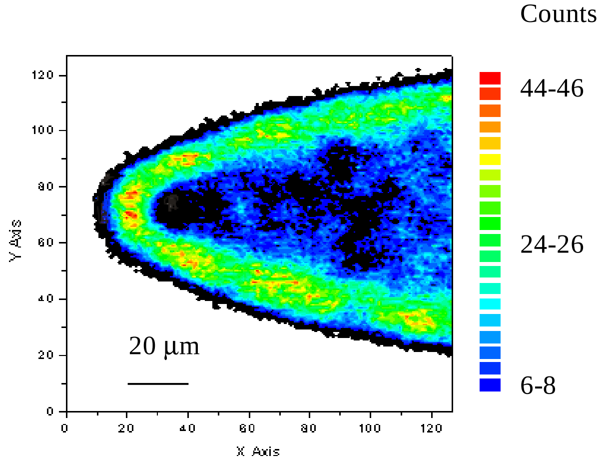

Fig. 3 Panchromatic diamond map of ion luminescence. The colour scale is proportional to the luminescence efficiency.

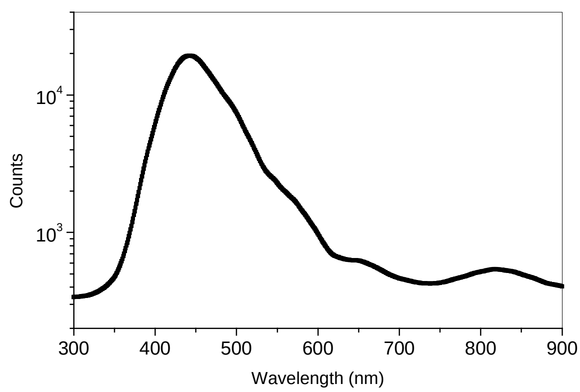

Fig. 4: IL spectrum of a diamond tip.

Diamond tips have also been characterised by means of ion luminescence. Fig.3 shows the panchromatic IL map from a diamond tip with a base diameter of 200 micrometer.

The image clearly shows the profile of the tungsten substrate (low luminescence regions) and the uniform coverage, 15 micrometer thick of diamond film on the tungsten tip. The luminescence spectrum is shown in Fig. 4. The "A band", around 420 nm, usually associated with dislocations, is clearly visible as well as the broad peak around 850 nm which is almost certainly created during ion irradiation.

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