A NEW MONITORING SYSTEM FOR BEAMS OF CHARGED AND NEUTRAL PROJECTILES

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Abstract

A new monitoring system has been designed, permitting to control the beams of charged and neutral projectiles. The monitoring system uses the detection of electron emission. This construction allows control the flux of the particles without interruption of the beam. The monitoring is independent of direct ion current being detected in course of the actual measurement. Therefore it lends itself ideally to the spectrum normalization for the insulating samples and in cases of low beam currents. This arrangement allows to control the projectile fluxes from 10^5 to 10^{13} particles/s·sm^2.

1 INTRODUCTION

The ion current must be controlled closely in particle beam studies. Ion beam current integration is often used to obtain the ion dose on irradiated targets either by measuring the current on target itself or through the target into a Faraday cup behind it. However, this measurement has sometimes proved difficulties:

1) The current to an insulating target cannot be measured directly.
2) For conducting targets errors in ion current measurement arise due to electron emission from the target.
3) Electrons from ion beam collimators near the target are carried along with the ion beam.
4) In the case of thin targets most of the beam is transmitted through the target and can be measured in a Faraday cup. However, depending on target material and thickness and the projectile species and energy, electron stripping can take place leading to a false measure of current at the Faraday cup.

Another method of spectra normalization uses projectile backscattering from a thin metal foil inserted into the beam line. It should be mentioned that a monitor foil in front of the target acts as a beam diffusor requiring good beam collimation behind to avoid an increase in beam line background.

The beam monitor presented here avoids all these problems, is totally independent of the target, and permits ion beam doses to be obtained without the necessity of measuring the ion current and interruption of the beam.

2 PRINCIPLE OF METHOD

Electrons are emitted from ion-atom collisions when protons pass through gas layer. The flow of emitted electrons is proportional to the beam current. Therefore, measurement the total electron current or current of any region of the electron spectrum can be used for beam monitoring. Fig.1 illustrates the method and the experimental setup for the measurements. All that is required for the monitoring beam is to interpose in the ion beam an electrostatic energy analyzer with the holes in the both of plates.

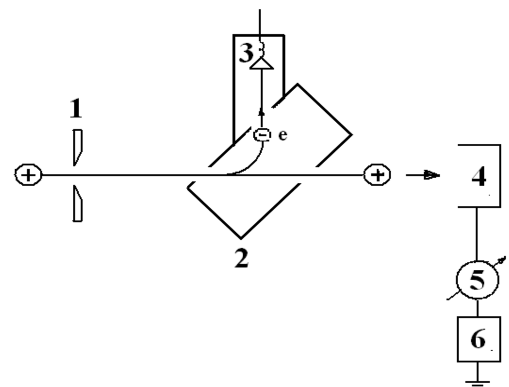

Figure 1: Experimental arrangement for beam monitoring. 1 - diaphragm; 2 - energy analyzer; 3 - channeltron; 4 - Faraday cup; 5 - ammeter; 6 - current integrator.

In our experiment we measured the flow of electrons, which are generated by protons of the beam passing through layer of the residual gas in collision chamber. The density of the gas layer and therefore the yield of the electrons depends on a residual pressure in the chamber. Proton beam was generated by the 500 keV ion accelerator of the Institute of Nuclear Physics of Moscow State University. The proton beam and electrons, generated by the protons, penetrate the diaphragm and pass the electrostatic energy analyzer. The current electrons at the output of the analyzer is registered by channeltron. The ions of the beam pass second plate of the analyzer and reach finally the Faraday cup for current measurement. The current of beam is measured by nano-ammeter connected with the Faraday cup and grounded through current integrator. In our experiment current of proton beam is varied from 50 pA to 1 μA. An upper limit to the current of monitored beam depends significantly on the count rate of the channeltron and, therefore, on the value of the input electron [1]. As for normal channel-multiplier operation, this is provided at a count rate of less than 10^5 Hz, which corresponds to input currents less than

10^{-14}A. All measurements are performed at a pressure in chamber of about 10^{-6} mbar.

3 RESULTS

An energy spectrum of the emitted electrons is presented in Fig. 2. The electrons are emitted as a result of the interaction 200 keV protons with the atoms and molecules of residual gas in the chamber. Clearly seen the peak of the convoy electrons which is centered at an energy which corresponds to equal velocities of ions and

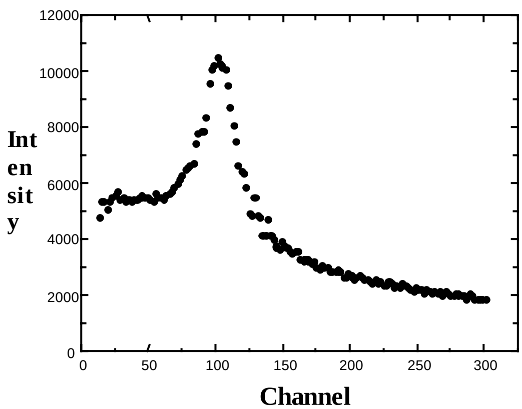

Figure 2: Energy spectrum of electrons generated by a 200 keV proton beam after penetrating a layer of gas of the vacuum chamber. A residual pressure in the chamber of $2 \cdot 10^{-6}$ mbar.

convoy electrons [2]. Convoy electrons are generated in the path of beam and move along with it.

In order to study the properties of proposed monitor we have measured the count characteristics of that arrangement as a function of beam current and of energy of the protons. The data accumulation system is automated and controlled by computer. Electrons having the required energy is selected from the spectrum by varying the voltage on the analyzer plates. Once the voltage on the electron analyzer is positioned, a computer command begins the scan by accumulating counts from the channeltron and from the beam integrator. Fig. 3 illustrates the electron counts in relation to the number of measurements. Energy of protons is equal 200 keV and proton current is equal 10^{-8}A in this measurement. The electron counts in singles measurements were normalized to the charge of beam current accumulated in the Faraday cup. The standard deviation of the electron counts is about 1%, including errors of the beam integrator.

We have measured electron count in the monitoring of beams neutral and charged particles. From these measurements we get that monitor allows to control beam in a wide range of projectiles flux from 10^5 particles / $s \cdot cm^2$ to 10^{13} particles/$s \cdot cm^2$ and over . Construction of the monitoring system permits to control flux of projectiles

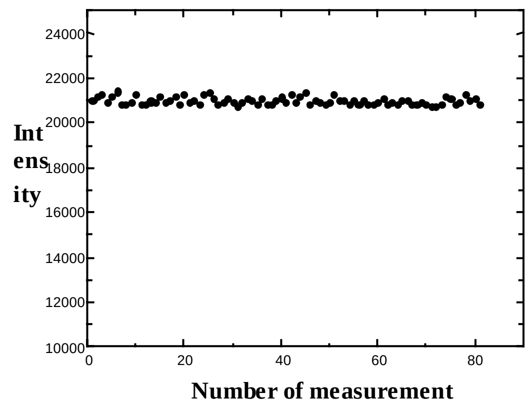

Figure 3: The electron counts as a function of the number of measurement. Each accumulating counts (one measurement) lasts for 30 second by integrating proton beam for a fixed number of microcoulombs.

without interruption in their journey. Since monitoring is independent of direct ion current readings during the actual measurement, it lends itself ideally to the spectrum normalization of thick insulating samples and in cases of low beam currents. The monitor of ion beam was used in the measurements of the transmission coefficient of X-rays of multilayer structures [3].

4 CONCLUSION

The method of monitoring of beams, which is described here, can be used in monitoring of projectiles over a wide range of energy from several tens of keV up to 10 MeV. The of particles therewith is not interrupted and yield of electrons is independent of type and condition of target. It permits to work with metal as well as insulating targets.

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