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SETUP FOR SECONDARY ELECTRON-ELECTRON EMISSION COEFFICIENT STUDY

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Abstract

Setup for measurement of secondary electron yield from metal surfaces and other materials is developed. This work is related to the well known problem of electron cloud formation in the synchrotron vacuum chamber during the beam passage. It is planned to measure the dependence of the second electron yield (SEY) on the chamber material type and the structure of the surface of the chamber wall. The constructed setup allows us to register the spectrum of secondary electrons.

ELECTRON CLOUDS

Electron clouds are clusters of secondary emitted electrons generated in the accelerator chamber due to acceleration of ionizing electrons of residual gas in electric field of the beam of particles in the accelerator and their resonance multiplication because of secondary electron emission from walls of the vacuum chamber of the accelerator. The character of this phenomenon is similar to the known effect of the multipactor – develop of discharge in cavities of RF devices. The density of electron clouds depends on the coefficient of secondary electron emission (K_{SEE}) of a material of the vacuum chamber.

Electron clouds that are present in accelerators and colliders with a high intensity beam form a positive feedback, which excites the instability of the beams. Generation of electron clouds also brings about an increase in pressure in the vacuum chamber, up to entire loss of the beam, because the formation of electron clouds is accompanied by desorption of gas molecules absorbed in walls of the chamber. In addition, the heat load on cryogenic surfaces of the vacuum chamber increases. An increase in pressure in the vacuum chamber also causes a rise in emittance of the beam due to scattering of the beam particles on the residual gas. In addition, the work of the beam testing instrument is defective because of electromagnetic disturbances initiated by secondary electrons.

Preliminary calculations of K_{SEE} for the vacuum chamber of the NICA Collider have shown that, for the material of a wall with K_{SEE} below 1.3, the effect is insignificant [1].

MESUREMENTS OF COEFFICIENT OF YIELD OF SECONDARY ELECTRON EMISSION

Measuring of the SEY coefficient was performed preliminarily at the setup [2] during irradiation of the studied sample by an electron beam with energy in the range of from 100 to 3000 eV. The principle scheme of the K_{SEE} measurement is shown in Fig. 1. The accelerated initial electron beam (I_1, E_1) hits the studied sample and knocks out secondary electrons from it (E_2, I_2). A negative potential is applied to the sample, and its value is chosen in the range of from –3000 to 0 V, depending of the chosen value of energy of incident electrons.

$$E_e = e(U_{cathode} - U_{anode}). \quad (1)$$

The primary and second electrons drift in the crossed electric **E** and magnetic **B** fields in the same direction transverse to the vector **B**. The values of **E**, **B** field are tuned in such a way that primary electrons come to the sample under studying and secondary electrons come to the collector. The collector is suspended under potential U_{coll} of the collector is measured. The K_{SEE} is determined from the values of primary beam current I_1 and secondary electron current I_2, which are equal to the current of the voltage source connected to the tested sample I_{sample} (Fig. 2). Full balance of the currents is described by the system of two equations:

$$\begin{cases} I_{sample} = I_1 - I_2 \\ I_{coll} = I_2 - I_3 \end{cases}. \quad (2)$$

Here I_3 is the current of the secondary electrons from the collector.

That gives the value of secondary electron emission coefficient:

$$SEY = \frac{I_1 - I_{sample}}{I_1}. \quad (3)$$

The dependence of K_{SEE} on the energy of the initial electron beam and on charge density imposed by the initial beam on the surface of the sample is measured in the experiments. Measurements will be performed without and with cleaning of the sample by sample heating that remove molecules of absorbed residual gas from the surface of the sample. Sample heater is based on electric bulb.

The first results of the stand work (see Fig. 3) showed that the stand works properly and the following results were obtained for a sample of steel at a vacuum of 10^{-7} tor: I_{gun} = 20 uA, I_{col} = 26 uA, I_{sample} = -7,5 uA, SEY=1,375.

Further vacuum condition improving, finalizing the sample holder, comparing the results with other installations is necessary.

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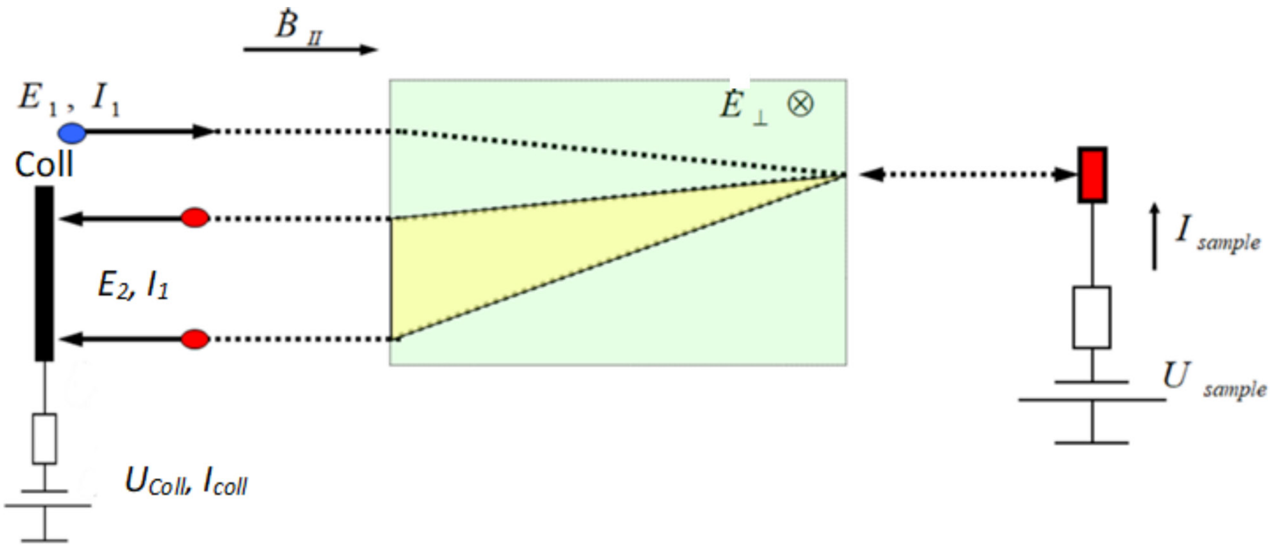

Figure 1: Principle scheme of measurement of K_{SEE}: E_1 and I_1 are the energy and current of the initial electrons, E_2 and I_2 are the energy and current of the secondary electrons which come to collector, U_{sample} is the potential of the sample, I_{sample} is the current of the source supplying the sample, $E_{\perp}$ is the transverse electric field, and $B_{\parallel}$ is the longitudinal magnetic field.

Figure 2: The gun, holder of the sample, the setup under assembling, scheme of the setup.

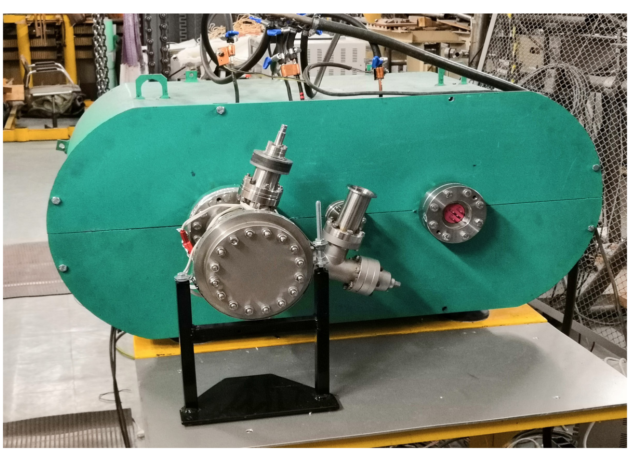

Figure 3: The stand for measurement SEY.

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