R5-P-003103

FEATURES OF SIMULATION OF CORPUSCULAR OPTICAL SYSTEMS FOR THE ANALYSIS OF CHARGED PARTICLE BEAMS*

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The features of simulation of energy analyzers of charged particle beams are considered. Since the limits of energy change in the methods of secondary electron spectroscopy lie in the range from a few keV to eV, electrostatic systems are predominantly used as energy analyzers.

Basically, when modeling and calculating corpuscular-optical systems, two directions were used to improve energy resolution, arising from the following formula $R=(\Delta L/D)\cdot\Gamma$, where R, ΔL, D, Γ are energy resolution, linear image smearing, linear energy dispersion and linear magnification, respectively. The first direction of research is associated with a decrease of ΔL, that is, an improvement of the focusing quality of charged particles beam or an increase of angular focusing order. The second direction is associated with an increase of D. There is also a third direction associated with the coefficient Γ. It was rarely taken into account, this is due to the fact that for the most common cylindrical mirror analyzer Γ=1. The need to take into account Γ arose in the study of rough surfaces, for example, discontinuity surfaces by method of Auger electron spectroscopy. The small magnitude of Γ of the system preserves the "tuning to the focus" in a wide range of variations in the cavities depth and the asperities height of the rough surface.

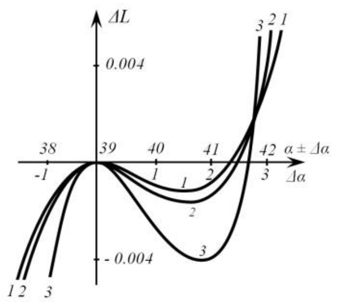

Fig.1. Aberration curves of a highly dispersive system for various parameters.

Let's consider one aspect concerning the first method. Decreasing ΔL improves the energy resolution, but decreases the luminosity of a device. This is primarily due to a decrease of the initial opening angle $\Delta\alpha$ of the charged particle beam. Information obtained from aberration curves can be useful. It can be seen from Fig.1, that the opening angle of the entrance beam can be taken from 38° to 41.5°. In this case, R=0.005% at luminosity 1.95% of 4π [1]. As another example, let's consider the electron-optical scheme of a hexapole-cylindrical analyzer corresponding to the following parameters: P=0.6 (reflection parameter relating the geometric and energy characteristics of the analyzer), $\alpha_0 = 43.742°$ (entrance angle of the axial trajectory into the analyzer field), $\Delta\alpha = \pm 8°$, D=1.7967, A_{III} =0.7340. The cubic aberration A_{III} in this scheme is not equal to zero, but it is small and at the same time has a maximum in the range of P. This means that the coefficient of spatial aberration of the next order A_{IV} at this point is equal to zero. This allows to conclude that the analyzer's angular focusing is close to ideal [2, 3]. The image smearing in a focus of an analyzer, caused by the angular divergence of a beam 16° in the axial plane, is determined by the cubic angular aberration $\Delta l = A_{III}(\Delta\alpha)^3$ and is equal to $\Delta l = 0.004$. Thus, a more detailed analysis of the aberration curves makes it possible to obtain a higher luminosity of the analyzer, while maintaining a high energy resolution.

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* The work was supported by the Ministry of Education and Science of the Republic of Kazakhstan under grant No. AP09058188.