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Durability of actinide targets and metallic foils in experiments on synthesis of superheavy nuclei

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Durability of targets and window foils irradiated by intense heavy ion (HI) beams in the experiments on synthesis of superheavy nuclei (SHN) carried out in Dubna with Gas-Filled Recoil Separator (DGFRS) has been considered. High fluxes of HIs and heat generated within relatively small areas and thicknesses of the target and foil used in DGFRS are inherent in such experiments. The ability of these elements to withstand radiation damages, sputtering and evaporation of atoms is critical for these long-term experiments. All the processes are influenced by the target (foil) temperature and none of them is independent of the others, but they can be considered separately.

Sputtering of actinide targets and Ti window foils irradiated by HI beams has been considered on the grounds of available models and experimental data. At present the ~1 pμA 48^Ca beam allows obtaining several atoms/month of SHN at the production cross section of few pb. The detailed study of SHN with 112≤Z≤118 produced in the 48^Ca fusion-evaporation reactions implies the use of higher beam intensities than those used in the discovery experiments. The synthesis of SHN with Z>118 implies the use of heavier beam particles. Expected production cross sections for SHN in these reactions are ≤0.05 pb. It means that for the observation of two decay events of such SHN one should collect the beam dose ≥10^20 particles. This dose of particles passed through a stationary target may cause the disappearance of target material at the end of the experiment if the sputtering yield is estimated as 10^-2 atom/ion (TRIM). In the case of the rotating target the yield of sputtered atoms is reduced by increasing the irradiation area. The question arises whether this estimate is reliable to be taken into account in future experiments.

The temperature of the target (foil) is determined by the power generated inside it and by the conditions of heat removal from a HI beam spot on the target (foil) surface. The temperature is estimated in the conditions of pulse heating followed by subsequent cooling with radiation emitted from their surfaces. Such pulsing mode corresponds to the rotating target and window irradiated by a continuous HI beam in the DGFRS experiments. Estimates show that radiative cooling is the most effective way of heat transfer to the surroundings at the temperature of few hundred Celsius degrees.

Selected session

Accelerators and Instrumentation

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