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Sputtering and heating as factors affecting the durability of actinide targets and metallic foils in experiments on synthesis of superheavy nuclei

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Sputtering of actinide targets, Ti target backing and window foils irradiated by intense heavy ion (HI) beams in long-term experiments has been considered on the grounds of available models and experimental data. Experiments on synthesis of superheavy nuclei (SHN), which are carried out with the Dubna Gas-Filled Recoil Separator (DGFRS), are the examples of such kind of experiments. High fluxes of HIs and heat generation, which are realized within a relatively small area and thickness of these elements of DGFRS, are inherent in such experiments. At present, the {48}^Ca beam with the intensity of about 1 pμA allows obtaining several atoms of SHN per month at their production cross section of several pb and an efficiency provided by DGFRS. The detailed study of properties of SHN produced in the experiments with the use of complete fusion-evaporation reactions induced by the {48}^Ca projectile on actinide target nuclei, which lead to nuclei with 112≤Z≤118, implies the use of beam intensities significantly higher than those used in the discovery experiments [1]. Moreover, synthesis of SHN with Z>118 implies the use of the beam heavier than {48}^Ca beam particles ({50}^Ti, {54}^Cr etc.). One may expect the production cross sections less than 0.05 pb for SHN formed in the fusion-evaporation reactions with these heavier projectiles. It means that for the observation of two decay events of SHN produced with this cross section one should collect the beam dose of 10^{20} particles if the 0.4 mg/cm^{2} actinide target and total DGFRS efficiency of 40% are implied. This dose of particles passed through a stationary target may cause total disappearance of radioactive target material at the end of the experiment if the sputtering yield of the material is estimated as 10^{-2} atom/ion [2]. In the case of the rotating target one can essentially reduce the yield of sputtered atoms due to the gain in the irradiation area. The question arises of whether these estimates are reliable to be taken into account in future experiments.

Heating the target and target backing foil as a single whole caused by an intense HI beam can be estimated with the use of some approximations. The temperature of the target and target backing is calculated as a function of time in the conditions of pulse heating followed by subsequent cooling with radiation emitted from their surfaces. Such pulsing mode corresponds to the rotating target irradiated by a continuous HI beam in the experiments. Estimates show that radiative cooling in the conditions of pulse heating can be the most effective way of heat transfer to the surroundings at the temperature of several hundred degrees. Such temperatures can be reached on the surfaces of the target and foils irradiated by HI beams at the intensities exceeding 10^{13} particles/s [3]

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[2]. J.F. Ziegler, SRIM-2013, http://www.srim.org.
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