Laser flash analysis of irradiated amorphous carbon stripper foils

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For high intensity operation at the planned FAIR accel erator, radiation-hard carbon stripper foils are of interes because they could provide intermediate charge states t SIS and replace both, the gas stripper at 1.4 MeV/u as wel as the foils stripper at 11.4 MeV/u. Fatigue due to cycli thermo-mechanical stress and additional stresses due to dif ferent thermal expansion coefficients of foil and mountin frame have to be understood in order to increase the life time [1, 2]. This report presents a first approach to measure the thermal diffusivity with the laser flash method of pristine and irradiated amorphous carbon (aC) foils. The diffusivity influences the heat transport and the temperature increase during irradiation.

The thermal diffusivity α, which contributes to the thermal conductivity $\lambda(T) = \alpha(T) \cdot c_p(T) \cdot \rho(T)$, can be accessed by laser flash analysis (LFA). The technique measures the temperature evolution of the front side of the specimen after applying a laser pulse (1064 nm, up to 25 J) to the rear side (c_p and ρ are the specific heat and the density). Measurements were evaluated by use of Cowan model [3]. The diffusivity is proportional to the square of the thickness l and the time after 50 % of the maximum temperature is reached at the front side $t_{0.5}$ ($\alpha \sim \frac{l^2}{t_{0.5}}$). This illustrates the importance of sample thickness determination. To measure the foil thickness by

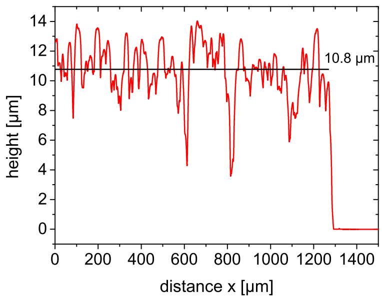

Figure 1: Profilometer scan across the edge of a pristine 709 μg/cm^2 thick aC stripper foil (produced by the GSI target laboratory) glued onto a silicon wafer.

means of profilometry the samples were fixed on a silicon wafer and height profiles across the edges of the foils were recorded (Fig. 1). The measurements reveal a great degree of roughness. As second method a thickness gauge was used. This method shows more consistent results (Fig. 2) than the profilometry and were therefore used for further diffusivity measurements.

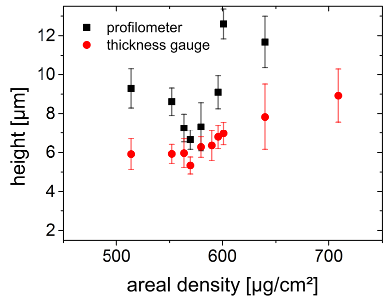

Figure 2: Foil thickness of pristine carbon foils for different deposited areal densities as determined by profilometry and thickness gauge measurements.

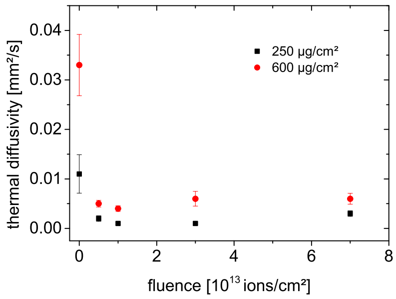

Figure 3: Thermal diffusivity of aC foils versus fluence of 4.8 MeV/u ^{238}U-ions. The 250 μg/cm^2 foils were irradiated behind the 600 μg/cm^2 thick ones.

First laser flash measurements on pristine and uranium irradiated aC foils of 250 μg/cm^2 and 600 μg/cm^2 are presented in Fig.3. Due to the very small value of thermal diffusivity of aC and the strong thickness dependence of α, the measurement values of the thin samples are very low. Nevertheless, for both foils a significant decrease by ion irradiation is observable starting at low accumulated fluences. Further work on the thickness estimation needs to be carried out to improve accuracy of the LFA measurements. More irradiated samples need to be measured by means of LFA technique to verify these results and to understand ion-induced disordering processes leading to diffusivity decrease.

References

[1] M. Tomut et al., GSI Scientific Report,p. 412, (2011)

[2] K. Kupka et al., GSI Scientific Report,p. 409, (2012)

[3] R. Cowan, Journal of Applied Physics, 34, pp.926-927(1963)

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