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Photothermal radiometry study of heavy ion beam induced modification of polycrystalline graphite thermal properties

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Polycrystalline graphite (PG) is one of the best candidate materials for applications in extreme radiation environments. It exhibits superior thermo-mechanical properties, resistance to elevated temperatures and stresses, low density leading to low linear energy transfer and reduced beam-induced activation. Recent studies report on ion beam induced hardening and increased electrical resistance of irradiated graphite materials [1]. Additionally, modifications of thermal properties leading to changes in efficiency of dissipation of the heat deposited by high intensity ion beam should be carefully investigated. In this work, the evolution of thermal effusivity and characteristic thermal diffusion time for polycrystalline graphite samples irradiated with 4.8 MeV/u and 5.9 MeV/u Au ions and with 4.8 MeV/u U ions at the UNILAC accelerator at GSI was studied using the photothermal radiometry (PTR) technique. PTR permits a non-destructive depth analysis and can evaluate the thermal properties of thin multilayer systems [2]. In this study, PTR is applied to characterize a 50-70 µm thick ion beam- damaged layer on pristine graphite substrate. The thickness value of the irradiated layer calculated by SRIM was experimentally confirmed by Raman spectroscopy and SEM imaging on the sample's cross-section. The results show a significant degradation of thermal effusivity down to 20% of the pristine value and a slight decrease of volumetric heat capacity of irradiated graphite at the maximum reached ion fluence of 5e13 i/cm2. The measured thermal properties of the irradiated layers reflect values characteristic to glassy carbon. This study can help in better understanding of swift heavy ion interaction with graphite and induced material modification.

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