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IRRADIATION EFFECTS IN CERAMICS FOR HEATING AND CURRENT DRIVE, AND DIAGNOSTIC SYSTEMS

Deliverable: ***Studies on radiation induced absorbtion of selected alternative radiation resistant glasses following displacement damage***

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1. Introduction

The present report is related to the research program started in 2004 on the modifications induced in the optical transmission properties by the high-energy proton irradiation of some quartz glass samples - candidate materials for the future fusion reactor. Consequently, in the first three months of the project – October, November and December 2005 - the study was focused on the interpretation of some results concerning the previously irradiated KU-1 and KS-4V glasses - see the dedicated report in this volume - and on the preparation of new irradiation experiments, with accent on the dosimetric aspects (proton, gamma and neutron contribution).

The optical transmission components of the future thermonuclear reactor will be expected to maintain their transmission properties under high levels of ionizing radiations (≈ 5 Gy/s) during hundreds of hours. For such applications, radiation-induced optical absorption imposes a severe limitation. It is therefore necessary to study the optical degradation of the suitable candidate materials, to assess the system lifetimes. KU-1 and KS-4V quartz glasses are among the main candidates insulator materials for the International Thermonuclear Reactor (ITER) project, due to the fact that they are known to be radiation-resistant. The KU-1 glass studies were started back in 2003 by using 12.6 MeV proton irradiation, because of the following advantages:

- at this energy, the displacement damages simulate quite well the 14 MeV high energy neutrons damages,
- *since a thin sample is irradiated, the damage is more uniform throughout the thickness.*

2. Results

The study of the proton irradiation-induced modifications of the UV transmission properties of KU-1 quartz glass started with irradiations performed in-air at the Bucharest 8 MV HVEC Tandem accelerator. The 0.8 mm thick KU-1 sample was irradiated up to a dose of 2×10^{14} protons.

Before irradiation, the range of 12.6 MeV protons in SiO_2 and the number of the collision events - vacancies produced by the protons in target depth were calculated using the SRIM 2003 code [1]. The 12.6 MeV energy of proton beam on the target was obtained after extracting the 13 MeV proton beam through a 50 μm Al foil, and by passing it through 2 cm of air (the distance between the extraction foil and the target).

The irradiation of KS-4V quartz glasses took place under similar conditions as the ones above described for 12.6 MeV irradiation, the only difference being the energy on the target, which, in this case, was 14 MeV; the irradiation doses were up to 5×10^{14} protons.

In order to cool and to measure the actual temperature on the target during the irradiation, an air-pressurized cooling system and a Cr-Al thermocouple glued on the samples were employed to monitor the temperature. During the irradiation and when using the cooling system, the thermocouple indicated a temperature on the target around 30 °C; when the cooling system was off, the temperature on the irradiation spot was 80 °C.

It is worthwhile mentioning that using 12.6 and 14 MeV protons for irradiation, a certain amount of radioactivity is induced in the sample. However, after 24 h the irradiated samples can be handled without any radiological risk.

In October-November 2005, the present study was concentrated on dosimetric aspects, determining the supplementary irradiation doses induced by the proton emitted gamma-rays and neutrons. The proton dose cannot be directly measured in the samples and it is theoretically calculated [2]. The preliminary determinations indicated supplementary 30% gamma and 20% neutron doses to the main proton dose for 12.6 MeV protons and only 20% gamma and 10% neutron doses for 14 MeV protons. These values were measured in a position very close to the irradiated sample, in standard irradiation conditions (graphite collimator and 50 μm thick aluminum extraction foil for the proton beam).

3. Conclusions

Next year, the dosimetric determinations for gamma and neutrons will be continued by employing dedicated standardized dosimeters recently acquired by the Radioprotection Department of our institute.

In 2006 new irradiations - in vacuum, with 14 MeV protons and with different proton doses and temperatures (up to 200 °C) - on other radiation-resistant glasses that will be mechanical prepared at CIEMAT, Madrid will be performed.

References

[1] http://www.srim.org/SRIM/SRIM2003.htm

[2] **Pells G.P. , Buckley S. N., Agnew P., Foreman A. J. E., Murphy M. J., Staunton-Lamber S. A. B.**, Culham/EEC Fusion Technology Task MAT-13, AERE R-13222 (1988).