LOW AND HIGH ENERGY ION IRRADIATION ON STRUCTURAL AND OTHER PROPERTIES OF CUBIC ZIRCONIA AND CERIA: FROM THE PERSPECTIVE OF NUCLEAR ENERGY MATERIAL

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The interaction of energetic ions/particles with matter results in the transfer of energy from the incident particle to the target material. This process, commonly referred to as 'irradiation', often results in defects creation and subsequent micro-structural changes in the material, e.g. deterioration of crystallinity, swelling, amorphization etc., eventually leading to a degradation of its properties. These effects, broadly termed/classified as 'radiation damage', have detrimental implications in vital fields of science and technology, e.g. nuclear, electronic & space industries, where the materials are subjected to severe irradiation with low energy and/or high energy particles during service. Radiation damage is thus an undesirable (and often unavoidable) consequence of ion matter interaction (i.e. ion energy loss in materials). Therefore, the search for ways to mitigate the radiation damage in materials is an area of research of immense technological significance. A common way to simulate the effects of such irradiations, within a limited time, is to use energetic ion beams from accelerators.

In the recent past, downsizing of materials to nano-dimension has received explosive attention and is being considered as an effective strategy in the context of reducing the radiation damage. This is due to the fact that grain boundaries (GBs) are defect 'sinks'; and therefore, GBs can lower the accumulation of irradiation induced defects and hence reduce the radiation damage. A query that emerges is whether the effect of grain size on the radiation tolerance the same in the high energy irradiation (HEI) regime i.e. dominated by electronic energy loss (S_e) as well.

Cubic zirconia and Ceria, potential materials for inert matrix fuels, with different grain sizes (tens of nanometers to few microns) was irradiated under different conditions (viz. single beam irradiation with high energy ($S_e>>S_n$) ions at 300 K and 1000 K& *simultaneous* dual beam irradiation with high and low energy ($S_n>>S_e$) ions at 300 K to investigate the effect of grain size, environmental temperature and electronic excitation (S_e)/ballistic processes (S_n) on the radiation damage. The irradiations at 1000 K and the *simultaneous* irradiations helped to better simulate typical nuclear reactor environment. In case of the single beam irradiations, (i) the nano-crystalline samples were more damaged compared to the micro-crystalline (i.e., bulk) ones irrespective of the irradiation temperature, and (ii) the damage for all grain sizes was found to be lower at 1000 K compared to that at 300 K - these observations being in contrast with results obtained previously with low energy irradiations. The nanocrystalline sample is however less damaged than its micro-crystalline counterpart upon the *simultaneous* low and high energy irradiations indicating better damage tolerance of the nano-crystalline state to simultaneous S_n and S_e deposition– this study provides the first realistic evidence towards the potential application of nano-materials over bulk in the nuclear industry.

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