Review of $A_2B_2O_7$ pyrochlore response to irradiation and pressure

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This article reviews recent research on swift heavy-ion irradiations and high-pressure studies on pyrochlores of the $Gd_2Zr_{2-x}Ti_xO_7$ binary [1–4]. Applying three complementary analytical techniques (synchrotron X-ray diffraction, Raman spectroscopy and transmission electron microscopy) allowed for the investigation of the response of pyrochlore to irradiation and/or pressure. The chemical composition of pyrochlore has a strong effect on the character and energetics of the type of structural modifications that can be obtained under pressure or irradiation: For Ti-rich pyrochlores, the crystalline-to-amorphous transition is the dominant process. When Zr is substituted for Ti, an order–disorder transformation to the defect-fluorite structure becomes the increasingly dominant process. Except for $Gd_2Zr_2O_7$, single ion tracks in pyrochlore consist of an amorphous core, surrounded by a crystalline, but disordered, defect-fluorite shell. This shell is surrounded by a defect-rich pyrochlore region. In contrast to similar effects observed when pressure or irradiation are applied separately, the response of the pyrochlore structure is significantly different when it is exposed simultaneously to pressure and irradiation. The combination of relativistic heavy ions with high pressure results in the formation of a new metastable pyrochlore phase. TEM and quantum–mechanical calculations suggest that these novel structural modifications are caused by the formation of nanocrystals and the modified energetics of nanomaterials.