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X-ray induced defects in advanced lithium orthosilicate pebbles with additions of lithium metatitanate

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Advanced lithium orthosilicate (OSi) pebbles with additions of lithium metatitanate (MTi) as a secondary phase have attracted international attention as an alternative candidate for the tritium breeding in nuclear fusion reactors. In this research, the formation of radiation-induced defects (RD) in the OSi pebbles with various contents of MTi was analysed using X-ray induced luminescence (XRL). After XRL measurements, the accumulated RD were investigate using electron spin resonance (ESR), thermally stimulated luminescence (TSL) and diffuse reflectance spectrometry.

The advanced OSi pebbles with additions of MTi are biphasic without solid solutions, and thus the formation mechanism and the structure of the formed RD during irradiation with X-rays is similar to the single-phase materials. In the XRL spectra, several bands with maxima at around 380, 420 and 810 nm were detected. The band at around 420 nm can be attributed to the formation of E' centres (≡Si·) in the OSi phase, while remaining maxima are the result of the additions of MTi. In the ESR spectra, at least three first derivative ESR signals with g-factors 1.93, 2.003 and 2.040 were detected and attributed to Ti^{3+} centres, E' centres and oxygen related defects. The TSL glow curves are complex and consist of several overlapped peaks between 300 and 450 K, while the TSL spectra consist of one main band with a maximum close to 450 nm. The blue emission was attributed to the radiative recombination of E' centres or some variants of oxygen deficiency centres with oxygen related defects. It is assumed that the additions of MTi can increase the probability for the recombination processes of primary RD in the advanced OSi pebbles during irradiation and thus reduce the formation of chemically stable radiolysis products, for example colloidal lithium particles, which can interact with the generated tritium and form thermally stable lithium tritide.

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