Effects of grain size on hydrogen isotope behavior in $LiTaO_3$

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Understanding the tritium behavior in breeder materials is essential for the safe and economic operation of fusion reactor. Previous studies have indicated that the tritium behavior in solid breeders is affected by micro-structure (grain size, grain boundary, porosity), temperature, purge gas condition, radiation effects, etc. In the present study, we focus on the effect of grain size on hydrogen isotopes behavior in ternary lithium oxide. $LiTaO_3$ was used for a test material because the hydrogen behavior in $LiTaO_3$ is relatively well understood and thus the effect of grain size on hydrogen isotopes behavior would be observed more clearly than other ternary lithium oxides, such as Li_2TiO_3 and Li_4SiO_4.

Single-crystal samples of different gain-size distributions were used: around (a) 5 μm, (b) 50 μm, and (c) 500 μm in average. Because single crystals are free from gain boundary and porosity, the effect of grain size can be solely observed. Deuterium was introduced into the single crystal samples by thermal absorption at high temperature in D_2O gas atmosphere. Then the thermal desorption spectroscopy (TDS) was employed to observe the deuterium release behavior from the samples. Comparing the shape and position of the desorption peak in the TDS spectra of different samples, the rate-controlling mechanism of deuterium release was analyzed, which basically moved from the surface processes to bulk diffusion with the increase of grain size and temperature. By means of computational simulation, the correlation between grain size and hydrogen isotopes behavior was modelled, and the isotope effects among hydrogen, deuterium, and tritium were evaluated. Finally the effect of grain size on tritium behavior in ternary lithium oxide was discussed.