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ION BEAM ANALYSIS OF He-IMPLANTED FUSION SOLID BREEDERS

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Introduction

Lithium-based ceramics (silicates, titanates, …) possess a series of advantages as alternative over liquid lithium and lithium-lead alloys for fusion breeders. They have a sufficient lithium atomic density (up to 540 kg*m-3), high temperature stability (up to 1300 K), and good chemical compatibility with structural materials. Nevertheless, few research is made on the diffusion behavior of He and H isotopes through polycrystalline structures of porous ceramics which is crucial in order to understand the mobility of gas coolants as well as, the release of tritium. Moreover, in the operating conditions of actual breeder blanket concepts, the extraction rate of the helium produced during lithium transmutation can be affected by the composition and the structure of the near surface region modifying the performance of BB materials

Objective

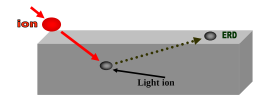
Study the He-implanted behaviour in Li-based fusion solid breeders.

ERDA was then the analytical technique used to in-situ analyze the depth profile of implanted ^4He at room temperature. The observed luminescence during analyses helped to understand the effect of ion bombardment on the ceramic crystalline structure.

This work is part of an extended study on the transport properties of light elements and tritium release in ceramic matrices considered good candidates as solid breeder blanket in fusion applications.

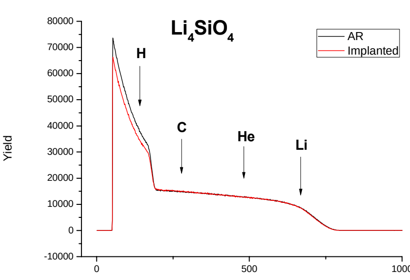
Experimental setting

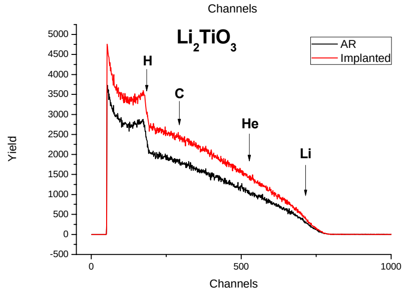
- Li-based ceramics Li_2TiO_3, Li_4SiO_4, were fabricated at CIEMAT: Li_4SiO_4, was sintetized in our laboratory by SiO_2 gel + lithium citrate; Li_2TiO_3 was prepared using commercial powder. Powders were then isostatically pressed at 2.5MPa,and sinterized at different Temperatures achieving porosities ranging between 60 and 80% of their TD .
- Samples were implanted at room temperature with ^4He with energy at an energy of .265 MeV , at a fluence of 1 x 10^{16} ions/cm^2 and at room temperature. Implantation were carrier out at the multipurpose experimental line at the 5MV terminal voltage tandem accelerator at CMAM facility in Madrid, Spain.
- Target materials were partially covered with a 4 µm thick Al sheet as beam degrader allowing a sample penetration of about 600 nm.
- Elastic Recoil Detection and Ion Luminescence spectra were recorded.
- For ERDA measurements a 25MeV Si beam was used.



Results

ERD ANALYSIS

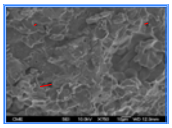




-In lithium silicate ERDA reveals the loss of H present in the matrix due to He implantation.

-In lithium titanate the Si^{4+} ion beam analysis reveals the presence of He remaining after implantation. NO entiendo esta conclusión si se implanta He lo normal es que se detecte He, no?

-The H peak shape suggests H accumulation in near surface regions in the Li_2TiO_3 ceramic which can be related to sample microstructure.

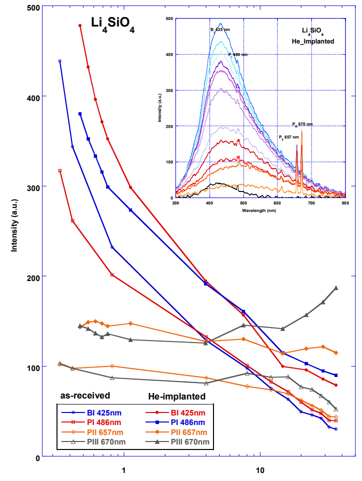


SEM image of a Li_2TiO_3 ceramic.

- **Transgranular fracture with monophasic poligonal grains with a size of about 10µm.**
- **The sample is highly porous. The pore size ranges from 1 to 10 µm.**

In-situ measured iono luminescence's pictures taken during ^4He implantation (left) and Si^{4+} characterization (right).

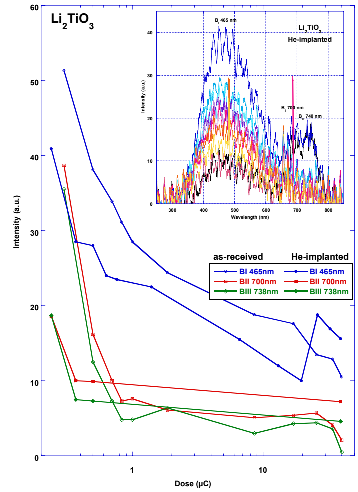
IONOLUMINESCENCE CHARACTERIZATION



-Four main luminescent processes occur while lithium silicate is being excited with high energy Si4+ ions. It is observed a broad band BI located at ~425nm and three singular peaks at 480nm (PI), 657nm (PII) and 670nm (PIII).

-The blue emissions (BI and PI) exhibit a light decay slower than the singular peaks appearing at long λ. The only significant feature is the great increase of PIII intensity after an irradiation dose of ~4 µC.

- Since both the as-received and He-Implanted samples exhibit the same features, it can be concluded that the implantation-induced defects do not introduce new luminescent emission bands.



-Three main luminescent processes occur while lithium titanate is being excited with high energy Si4+ ions: BI at ~465nm, BII at ~700nm and BIII at ~738nm.

- He-implantation does not significantly modify the luminescence response of as-received lithium titanate.

-The light extinction rate isa little quicker in case of BII and BIII.

-The red coloured emissions (BII and BIII) are both extinguished after very low doses (lower than 1µm) Esto no es una dode.

-Irradiation with a Si beam induced significant changes in the IL response of this material.

- Spectra analysis is being made to identify the defect transitions related to luminescent bands.

Conclusions

- **Light ion diffusion (implanted He and intrinsic H) seems to be affected by the material microstructure (porosity, composition, phase structure, surface finish…).**
- **High energy ion bombardment (Si^{4+}) induce H and He elimination in Li4SiO4 but H redistribution in Li_2TiO_3. (Noentiendo esta conclusión)**
- **He implantation does not significantly modify the defect structure in any of the studied ceramics. Con el haz de Si te cargas la muestra basicamente.**
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