Spark plasma sintering of actinide containing materials for nuclear fuel studies

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Highlights

- SPS facility devoted to study radioactive materials
- SPS sintering of UO_2
- Preparation of low grain size compacts

1. Introduction

Nuclear fuel undergoes a significant restructuration during its lifetime in the nuclear reactor. Especially at the rim of the pellet, large UO_2 grains disintegrate into a nanosized material. In this paper, we focus on the preparation of bulk UO_2 with grain sizes below 1 μm to investigate the physico-chemical properties of this so-called "high burn up structure" (HBS). Preparation of bulk nanocrystalline materials is a challenge that can be overcome using at first the conventional spark plasma sintering (SPS) [1] and later the high-pressure spark plasma sintering (HP SPS) technique [2].

2. Methods

We used successfully integrated SPS device into a hermetic glovebox, this configuration enables handling of highly radioactive material containing radioisotopes of U, Th, Pu, Np, and Am. The glovebox implantation has been facilitated by the replacement of the hydraulic system to apply pressure with a compact electromechanical unit [3]. Several types of UO_2 starting powder were used for the sintering studies (commercial powder from ADU process, powder from oxalate conversion or sol-gel process).

3. Results and discussion

We studied the SPS and HP SPS processing of various UO_2 powders. Generally, UO_2 powder can be sintered in SPS at 1000°C with 5 min dwell time compared to 1600°C and 6 hours of conventional sintering. Thanks to the adjustment of SPS sintering dense UO_2 pellets with a grain size as small as 300 nm were obtained by sintering at 835°C without dwell time. Further, the HP SPS using 500 MPa yielded dense (>90%) compacts with grain size as low as 34 nm for samples sintered at 800°C (see Figure 1).

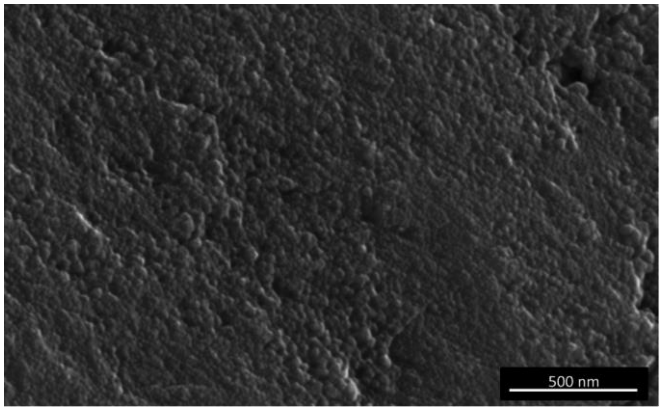

Figure 1. Scanning electron micrograph of HP SPS samples quenched from 835°C.

4. Conclusions

The SPS and HP SPS processing of UO_2 enable successful preparation of low grain size compacts, which can be studied as surrogates of nuclear fuel in the real fuel cycle.

References

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Low grain size, high pressure, uranium dioxide.