

## Recovery and Restructuring induced by Fission Energy Ions in High Burnup Nuclear Fuel

M. Kinoshita<sup>1,2,3</sup>, K. Yasunaga<sup>4</sup>, T. Sonoda<sup>2</sup>, A. Iwase<sup>5</sup>, N. Ishikawa<sup>1</sup>, M. Sataka<sup>1</sup>, K. Yasuda<sup>4</sup>, S. Matsumura<sup>4</sup>, H. Y. Geng<sup>3</sup>, T. Ichinomiya<sup>6</sup>, Y. Chen<sup>3</sup>, Y. Kaneta<sup>3</sup>, M. Iwasawa<sup>2</sup>, T. Ohnuma<sup>2</sup>, Y. Nishiura<sup>6</sup>, J. Nakamura<sup>3</sup>, Hj Matzke<sup>7</sup>

<sup>1</sup>JAEA Japan Atomic Energy Agency, Tokai-mura, Naka-gun, Ibaraki-ken, 319-1195, Japan;

<sup>2</sup>Central Research Institute of Electric Power Industry, 2-11-1 Iwadokita, Komae-shi Tokyo,

201-8511, Japan; <sup>3</sup>School of Engineering, The University of Tokyo, Hongo 7-3-1, Bunkyo-ku,

Tokyo 113-8656, Japan; <sup>4</sup>Faculty of Engineering, Kyushu University, 744 Motoooka, Nishi-ku,

Fukuoka-shi, 819-0395, Japan; <sup>5</sup>Dept. of Material Science, Osaka Prefecture University, 1-1

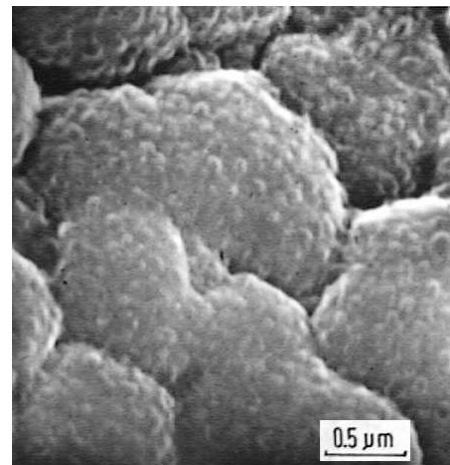
Gakuen-cho, Nakaku, Sakai, Osaka 599-8531, Japan; <sup>6</sup>Research Institute for Electronic

Science (RIES), Hokkaido University, Kitaku, Sapporo city, 060-0819, Japan, <sup>7</sup>Academy of

Ceramics, Institute of Trans-Uranium Elements, Karlsruhe, Germany.

The light water reactor fuels, ceramics of UO<sub>2</sub> and mixed oxides form the "rim-structure" above burnup of 70 MWd/kgU at temperature below 1100 °C. Grains are sub-divided into sub-micron diameter and extensive porosity is developed. The research is motivated by intensive engineering concern and interest in peculiar Cauliflower-like morphology, which has two scales of 1 and 0.1 μm. Trials are made to reproduce the process outside of the reactor and to reveal the principal mechanism of formation.

Combined irradiation of Xenon implanter and fission energy Tandem machine successfully reproduced the sub-grain formation in CeO<sub>2</sub>, the simulating material of UO<sub>2</sub>. Computer science methods, including calculation of first principle, molecular dynamics (MD), and accelerated MD, are applied. Among the kinetic processes to form the rim-structure, stabilization of planar fault by Xenon, crystallographic ordering induced by excess oxygen, fast transporting mechanism of oxygen clusters, are discovered and investigated in detail.



Surface of high burnup UO<sub>2</sub> fuel