Joint Research Centre

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Electron Microscopy Laboratory

Studies of Nuclear Materials

The Electron Microscopy Laboratory is equipped with Scanning Electron Microscopes (SEM) and a Transmission Electron Microscope (TEM) adapted for the examination of radioactive materials. Microstructure of different materials can be observed at very high resolution and very high magnification revealing details close to the size of an atom. Various subjects are studied in conjunction to use of nuclear materials.

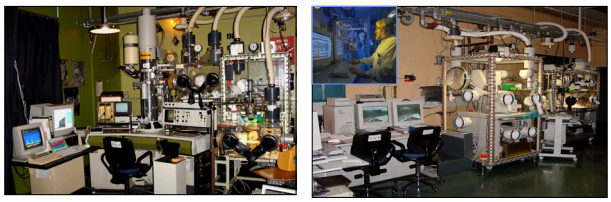

Fig.1: TEM Hitachi H700ST (left) and its series of glove-boxes and SEM Philips XL40 (right).

Fuel safety

The nuclear fuels are investigated with the aim of understanding their behaviour during irradiation in reactor in normal operating conditions but also in accidental condition. The microstructure is a key parameter to explain the various other properties measured like thermal conductivity, fission gas release, etc.

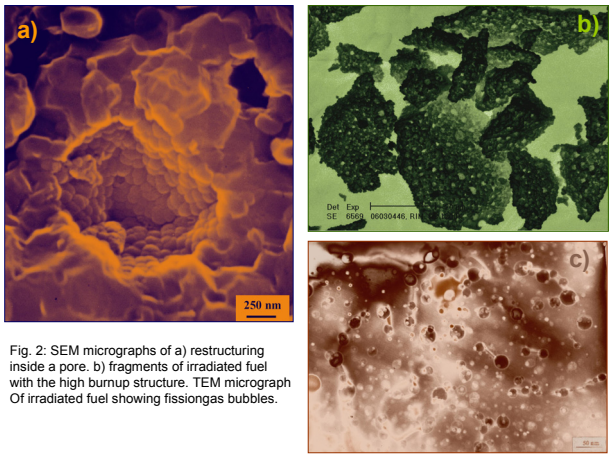

Fig. 2: SEM micrographs of a) restructuring inside a pore. b) fragments of irradiated fuel with the high burnup structure. TEM micrograph Of irradiated fuel showing fissiongas bubbles.

Radiation damage and spent fuel studies

Spent fuels will be stored or disposed off for very long periods of time. Laboratories studies aim at understanding and predicting the long term behaviour of fuel by performing ion implantation for example, creating tunable radiation damage.

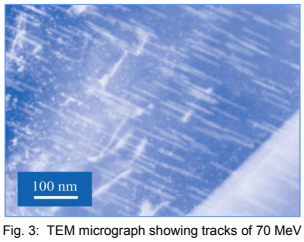

Fig. 3: TEM micrograph showing tracks of 70 MeV iodine-ions in $Nd_2Zr_2O_7$.

Inert matrix for the transmutation of minor actinides and waste conditioning matrices

To reduce the amount of nuclear waste several options are investigated. Transmutation of minor actinides (following reprocessing) in materials that do not produce new radiotoxic elements compared to conventional fuels. Also storage of the most radiotoxic elements in conditioning matrices and re-use of the uranium and plutonium would reduce the global amount of waste. These different materials needs o be tested for their long term capacity to withstand radiation damage.

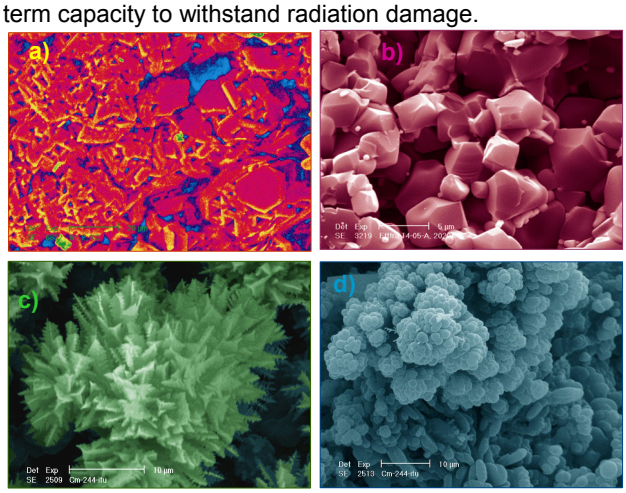

Fig. 4: SEM micrographs of a) zirconolite 3-M doped with plutonium-238. b) $MgAl_2O_4$ spinel inert matrix containing americium. c, d) curium sesquioxide showing dendrites or globules.

Nuclear forensic studies

Several cases of illicit handling of nuclear materials have been observed in recent years. Electron microscopy is one of the tools deployed to characterise the materials with the aim of answering questions regarding their composition, origin, intended use, etc.

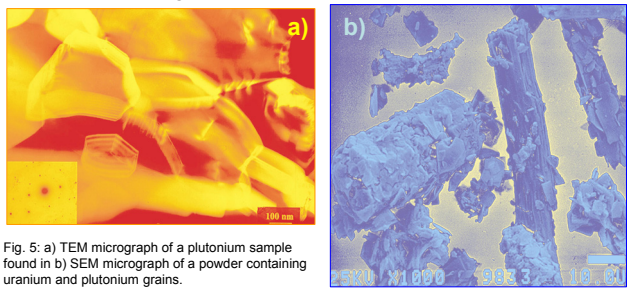

Fig. 5: a) TEM micrograph of a plutonium sample found in b) SEM micrograph of a powder containing uranium and plutonium grains.

Conclusion

Electron microscopy is a powerful tool for material characterisation at very high magnification.

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