INSPYRE
Investigations Supporting MOX Fuel Licensing in ESNII Prototype Reactors

FIRST SCHOOL QUIZZ

The right answers are indicated in red.

Marjorie Bertolus

What is NOT an objective of INSPYRE?
To utilise out of pile separate effect investigations to underpin basic phenomena governing fuel behaviour with soundly based physical models. This approach is applied to four important operational issues: Margin to fuel melting; atom transport and fission product behaviour; evolution of mechanical properties under irradiation; fuel thermochemistry and interaction with the cladding

- To perform additional examinations on selected irradiated samples to yield data when too little is currently available
- To develop and test mitigation strategies against corrosion/erosion/dissolution due to liquid metal and gas
- To use the models developed using a combination of the results of separate effect experiments, physical modelling and simulation, and integral neutron irradiation tests to enhance the efficacy of operational fuel performance codes and to improve their reliability in normal and off-normal situations.

Stéphane Bourg

The current French nuclear fuel cycle

- Produces 1200 tons per year of spent fuel
- Allows the recycling of 1 ton of plutonium
- Consumes 70 tons of uranium
- Does not require the mining of natural uranium

Lorenzo Malerba

Which effects of irradiation are amongst the main sources of concern in the case of structural materials for nuclear reactors?

- Softening and creep
- Swelling and embrittlement
- Liquid metal embrittlement and thermal creep
- Creep and fatigue

Pär Olsson

If you want to study a process that is controlled by diffusion, such as the dynamics of clustering of defects, the most appropriate choice of method currently is:

- Density functional theory
- Molecular dynamics using empirical potentials
- Kinetic Monte Carlo
- Cluster dynamics

Rudy Konings

The oxygen potential of $UO_{2\pm x}$ changes several orders of magnitude around $x = 0$ because of

- The structure change from face-centered cubic to tetragonal for x > 0
- Oxidation of the (111) surfaces at the grain boundaries
- The formation of extended defect clusters at x> 0 that are not formed for x<0
- Formation of O-vacancies for x<0 and O interstitials for x>0

Romain Vauchy

In the SFR fuel manufacturing, what are the main specifications for composition?

- Pu content > 20% & O/M ratio > 2.00
- Pu content < 20% & O/M ratio > 2.00
- Pu content > 20% & O/M ratio between 1.94 and 2.00
- Pu content < 20% & O/M ratio between 1.94 and 2.00

Marjorie Bertolus

Which organisation(s) is(are) member(s) of the user group of INSPYRE

- GIF Forum
- ESNII
- Falcon Consortium
- ORANO

Jean Noirot

Electron probe micro analyzers (EPMA)

- Provide element maps and quantitative analyses
- Are used to measure He production during irradiation and storage
- Are used to measure all the fission gases retained in the samples
- Have been adapted to measurements on irradiated fuels and materials by internal shields

Lorenzo Malerba

Which degradation processes define the operation temperature window of nuclear structural materials?

- Swelling and irradiation creep
- Liquid metal embrittlement and thermal creep
- Radiation hardening/embrittlement and thermal creep
- Erosion and corrosion

Stephane Bourg

In the simulated French fast reactor fuel cycle

- About 70 tons of plutonium are recycled annually
- About 50 tons of uranium from the stockpile of depleted uranium are requested for manufacturing the MOX fuel
- The recycling of Americium allows the production of 10% more of electricity compared to the recycling of U and Pu
- The total volume of waste to be disposed of in underground repository is higher than the volume of the same kind of waste in the current French fuel cycle.

Rudy Konings

The restructuring of Fast Reactor fuel with the formation of a central void is mainly caused by

- Centerline melting of the fuel
- Resintering of the fuel pellets
- Mass transport via vapor along a temperature gradient
- Solid state and grain boundary diffusion

Alessandro Alemberti

How many different reactor systems have been chosen as a basis for Generation IV International Forum (GIF) activities?

- None
- 4
- 6
- 10

Christine Guéneau

How is the oxygen potential of MOX fuel compared to UO2 fuel for given temperature and oxygen stoichiometry conditions?

- Lower
- Equal
- Higher

Marie-France Barthe

What is(are) the main advantage(s) of ion Irradiations for the study of materials behaviour under irradiation?

- Simulation of neutron irradiation
- Low cost
- Flexibility
- No activation

Jean Noirot

Columnar grains are

- Present after sintering during fuel fabrication
- Formed at high burn-up in the centre of the fast reactor fuels
- Formed at the beginning of the irradiation for locally high linear heat rates
- Due to fuel fragmentation

Elio D'Agata

What is the suggested maximum amount of Americium at the Beginning of Irradiation for Minor Actinide Driver Fuel:

- Up to 5%
- Up to 10%
- Up to 15%
- Up to 20%

Christine Guéneau

How does the oxygen potential of MOX fuel vary with burnup?

- It increases
- It remains equal
- It decreases

Pär Olsson

Molecular dynamics is

- Much faster than density functional theory
- How to solve the Schrödinger equation
- A method of advancing a many-body system in time
- A way to move atoms from lattice site to lattice site

Lauren Flint

Which is the correct order for the safety hierarchy of controls (going from most effective to least effective)

- Elimination, Engineering Controls, Administrative Controls, Substitution, personal protective equipment (PPE)
- Elimination, Substitution, Engineering Controls, Administrative Controls, PPE
- PPE, Elimination, Engineering Controls, Substitution, Administrative Controls
- Engineering Control, Administrative Controls, PPE, Elimination, Substitution

Romain Vauchy

In the SFR fuel manufacturing, why is the sintering step so challenging?

- Because a demixtion can occur during cooling leading to a destroyed microstructure
- Because Pu is radioactive
- Because of the competition between densification and formation of solid solution
- Because the final O/M ratio depends upon the sintering conditions

Lelio Luzzi

Fuel Performance Codes allow analysing and simulating the thermo-mechanical behaviour of:

- reactor core
- fuel assembly
- individual fuel pins
- fuel only

Andreas Geist

Why would one want to recycle americium?

- to reduce long-term radiotoxicity
- to reduce the footprint of a final high level waste repository
- to reduce the time required for safe enclosure in a final high level waste repository from 100,000s of years to centuries
- to reduce the cost of the nuclear fuel cycle by recycling fissile material

Jean Noirot

The High Burn-up Structure (HBS)

- Forms all over the pellets above 7 at% in fast reactor fuels
- Is a restructuration of the initial grains in smaller grains with large fission gas bubbles
- Due to epithermal neutron absorption in the rim of the fast reactor pellets
- Has been a major concern since the beginning of the Fast reactors

Andrea Rineiski

In pins, molten fuel motion in intact pins during the transient

- Is more probable in non-hollow (initially without central hole) pins
- may introduce a negative reactivity effect
- may delay clad failure

Elio D'Agata

Which gas(es) is(are) major concern(s) during irradiation of fuel containing Minor Actinides?

- Helium
- Tritium
- Xenon
- Hydrogen

Binh Dinh

To characterize the affinity of an extractant towards a metallic species what should we use?

- The extraction factor
- The distribution coefficient
- Solvent loading with this species
- The mass transfer kinetics of this element

Lelio Luzzi

Fuel pellet cracking is an effect of:

- neutron irradiation
- radial temperature gradients
- fission product generation
- microstructural changes

Andrea Rineiski

In pins, molten fuel motion in intact pins during the transient may occur

- due to gravity
- due to pressure gradients
- during slow transients
- during fast transients

Marie-France Barthe

Which parameter(s) impact(s) the range of ions in matter?

- Target composition and density
- Target temperature
- Ion energy
- Ion mass

Lauren Flint

Who is a criticality assessor's best friend?

- MAGIC MARK
- MAGIC MARY
- MAGIC MERV
- MAGIC MAYA

Andrea Rineiski

The SAS4A accident analysis code is NOT applicable for SFR transient analyses after

- first power excursion
- clad melting
- can-wall melting
- fuel melting

Marie-France Barthe

What type(s) of machines can be used to irradiate materials with ions?

- Cyclotron
- Van de Graaff
- Synchrotron
- Tandem

Andreas Geist

A well performing solvent extraction process should be / is typically

- Multi-stage, counter-current
- Multi-stage, co-current
- Continuous, multi-stage
- None of the above

Alessandro Alemberti

How many industrial initiatives are supported by the Sustainable Nuclear Industrial Initiative (ESNII)?

- None
- 4
- 6
- 10

Lorenzo Malerba

Which degradation processes define the operation temperature window of nuclear structural materials?

- Radiation hardening/embrittlement and thermal creep
- Swelling and irradiation creep
- Liquid metal embrittlement and thermal creep
- Erosion and corrosion

Binh Dinh

In a multistage extraction operation in countercurrent flows (aqueous and organic)

- The KREMSER formulae can be applied to evaluate the extraction work achieved if the organic and aqueous ratio, as well as the distribution isotherm, are known.
- The KREMSER formulae can be applied to evaluate the extraction work achieved if the extraction factor is constant in the whole countercurrent set-up.
- For an extraction factor of 10 and a number of stages of 3, the non-extracted fraction remaining in the aqueous outlet of the set-up represents 3% of the matter contained in the aqueous inlet.
- For an extraction factor of 10 and a number of stages of 3, the non-extracted fraction remaining in the aqueous outlet of the set-up represents 0.1% of the matter contained in the aqueous inlet.

Rudy Konings

The fission product iodine is present in nuclear fuel as

- Cesium iodide as this is the stable form according to thermodynamics
- Molecular iodine in gas bubbles in the matrix and grain boundaries
- Tellurium iodide as iodine decays to tellurium
- Atomic/molecular iodine as gamma radiation destroys metal iodide compounds

NOT INCLUDED

Lelio Luzzi

PCI-related effects can be evaluated, in complete detail, by means of:

- *BISON*
- *FALCON*
- *FEMAXI*
- *TRANSURANUS*

Marie-France Barthe

What are the techniques that can be used to have a direct characterization of defects in UO2?

- *Atom probe tomography*
- *Transmission electron microscopy*
- *XRD*

- *Positron annihilation spectroscopy*

Jean Noirot

In fast reactor pins, the fission gas release rate is

- *Generally high*
- *Improving the gas thermal conductivity inside the pin*
- *Retained in the Sodium*
- *Generally increasing with burn-up*