SP3 – Presentation

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Archer
Advanced Reactor
for Cogeneration of
Heat & Electricity-R&D

SP3 Fuel & Fuel cycle

WP31 - Fuel Basic Properties

- Post irradiation examination of PYCASSO coated particles
- SiC properties and fission product diffusion
- Neutron damage of pressurised coated particle layers (CPSTRESS)

WP32 - Integral fuel element irradiation performance and safety testing

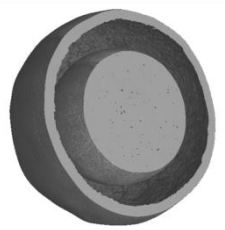
- Post irradiation examination HTR fuel
- HTR fuel safety testing
- HFR-EU1 irradiation modelling

WP33 - Open cycle - HTR fuel disposal

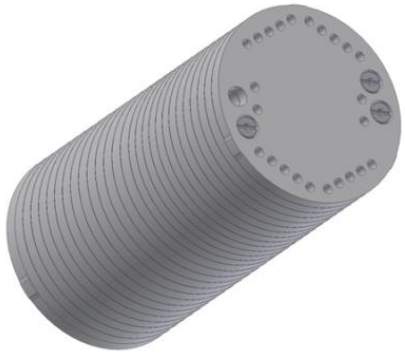
Open cycle - HTR fuel disposal

WP31 – Fuel Basic Properties

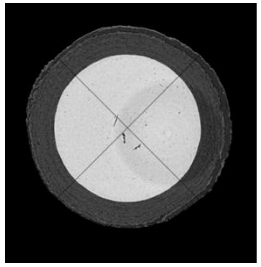
Post irradiation examination of PYCASSO coated particles: X-ray tomograph at NRG

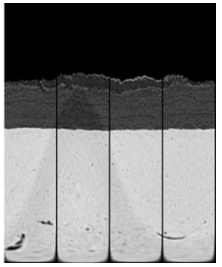


PYrocarbon irradiation for Creep And Swelling/Shrinkage of Objects (part of RAPHAEL). Irradiation experiment to study coating behavior of coated particles at high temperatures



kernel/layer(s) diameter/thickness(es) [um]	
kernel/buffer 1000/250	
kernel/buffer/PyC 1000/250/40	
kernel/buffer/SiC 1000/215/35	
kernel/buffer/SiC/PyC 1000/215/35/40	





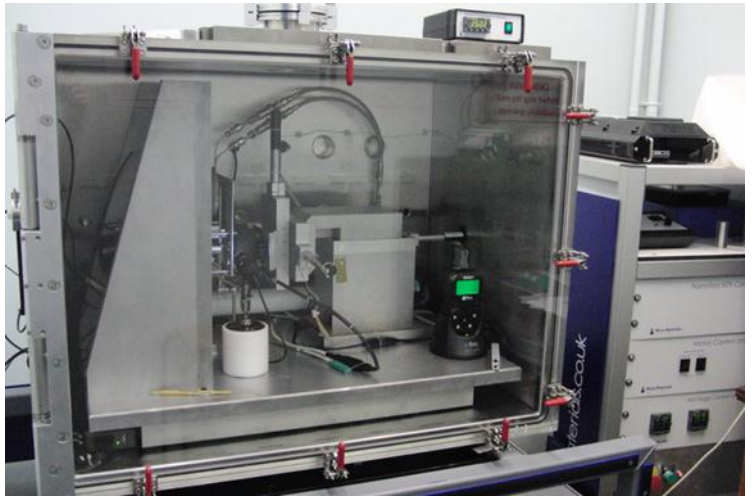
- **Resolution of 2 μm requires 1 hour measurement**
- **Should provide information concerning irradiation creep of PyC**

WP31 – Fuel Basic Properties

Post irradiation examination of PYCASSO coated particles:

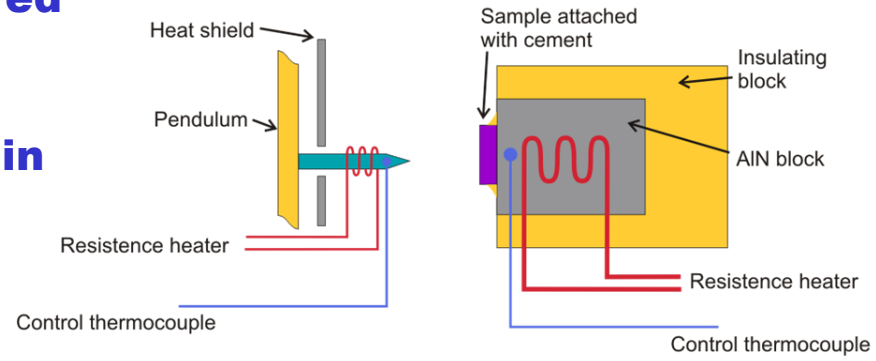
High Temperature Nanoindentation at UMAN

Capable of testing coating cross sections and surfaces as well as bulk materials to investigate hardness and modulus up to 500 °C (up to now)



- Similar evolution of the elastic modulus measured by nanoindentation and Raman spectroscopy

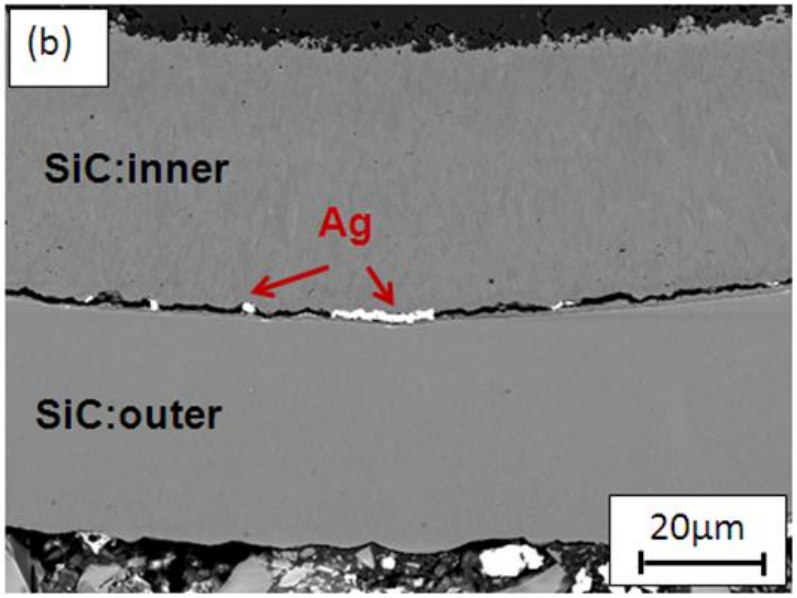
- Strong reduction of hardness with temperature in agreement with literature



WP31 – Fuel Basic Properties

SiC coatings and Ag diffusion

- Study Ag migration through the SiC in UMAN
  - Generally considered phenomena: Grain boundary diffusion / Nanocracks / Palladium
- Find some SiC coatings prone to stop Silver migration



A new model for Ag migration through SiC coatings was proposed

- Dissolution/reaction-recrystallization model

WP31 – Fuel Basic Properties
SiC coatings and Cs, I diffusion

- TRISO particles in presence of diffused elements:
  - I (I2 and NaI)
  - Ag (metallic silver, AgI, AgCl)
  - Cs (CsCl)

- Instead of having the diffusion process from the inside of the coated particle, the diffusion process is taking place form the outside (CPs being housed in quartz tube)

- Different temperatures between 1050˚C and 1300˚C for annealing time from 24 to 85 hours.

- Different PIE techniques were performed (in progress)

WP31 – CPSTRESS irradiation

Design and feasibility study for ARCHER

Goals:

- Ag diffusion under irradiation
- Evolution of coated particles mechanical properties while irradiated with an internal pressure in the buffer layer (B_4C).

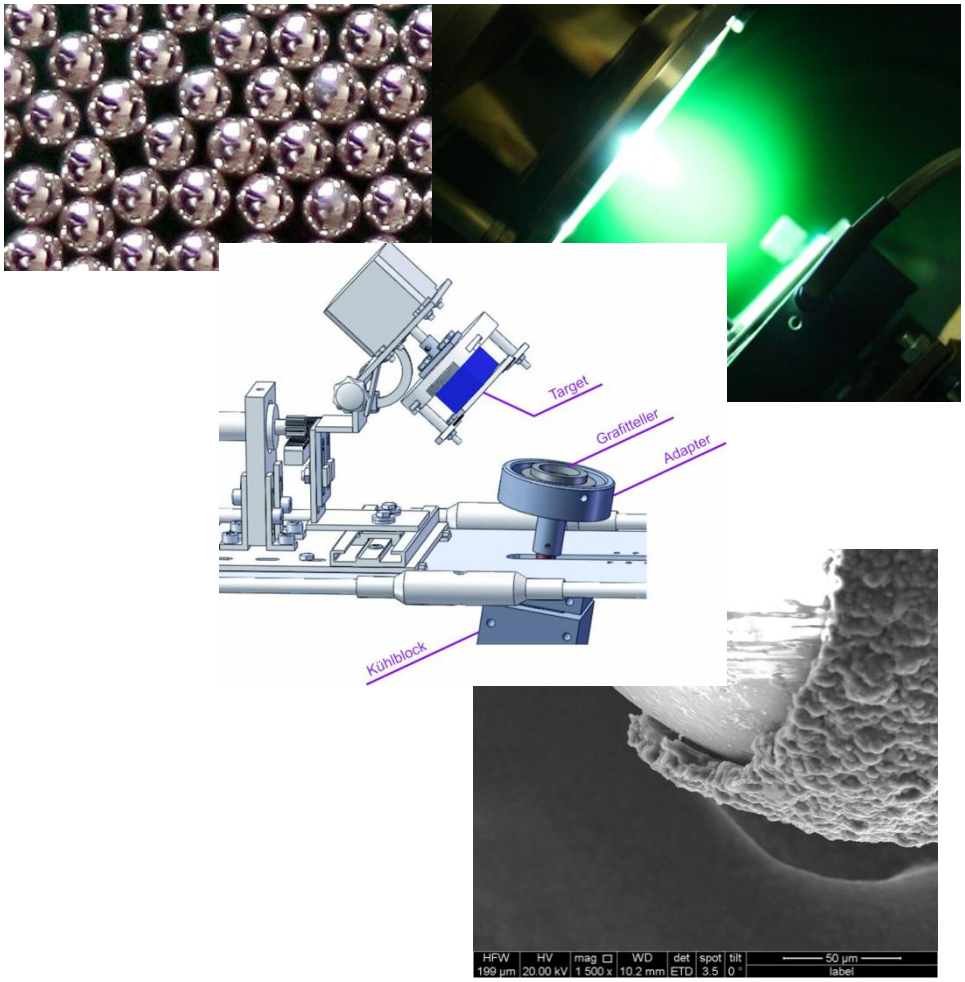
- Two temperatures targetted: 1000-1200˚C
- Fluence: ~up to 5.10^{25} m^{-2} (higher than for PYCASSO)
- Duration: about 13 cycles in the HFR
- 5 dpa in carbon can be expected
- Pressure in the CP up to 350 MPa by the use of boron carbide

NRG in collaboration with INL: Irradiation requirement (temperature, fluence) by the mean of PERFUME calculations

WP31 – Fuel Basic Properties

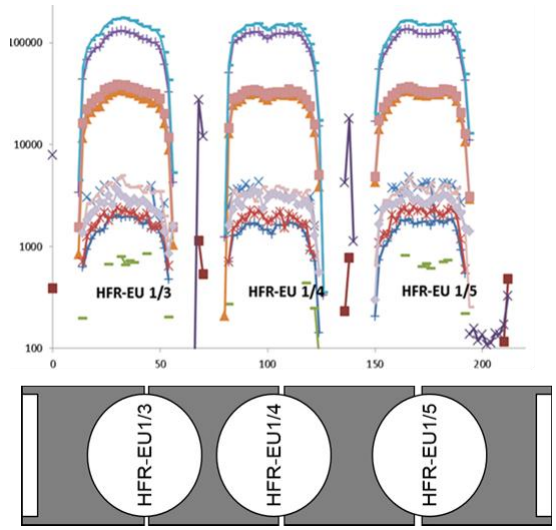
Fabrication reports for CP STRESS Ag and B_4C doped coated particles

- **PLD process in TU Dresden**
  - Coating setups developed for high Boron thickness
  - Overcoating of the Ag layer with protective SiC coating for compatibility with CVD coating process
  - Achievement of 25 µm thickness in B_4C layer (350 MPa targeted with enriched B_4C)
  - Overcoating by CVD process (UMAN)



WP32 - Integral fuel element irradiation performance and safety testing

HFR-EU1 pebbles scrutinized in Petten (NRG)
Two pebbles transported in ITU for PIE



SAFETY TESTING and associated PIE to be discussed in the next presentation

WP32 - Integral fuel element irradiation performance and safety testing

Neutronic modelling of the HFR-EU1

HFR-EU1irradiation modelling by IRSN

- **VESTA 2.1.5 code IRSN has been updated in late 2012 and made available in February 2013**
- **HFR-EU1 calculations**

Fuel performance modelling of HFR-EU1 under normal and off normal conditions

- **AREVA calculations with ATLAS**
- **FZJ calculations**

WP33 - Open cycle - HTR fuel disposal

Open cycle - HTR fuel disposal

- high stability of SiC under reducing conditions established in the autoclaves
- Alteration at 90°C under air

Recommendations and documentation on spent HTR fuel management

Alteration solution:

- COX Water

Temperature:

- 50°C
- 90°C

Atmosphere:

- H_2 5%/N_2
- Air