EERA Joint Programme Nuclear Materials

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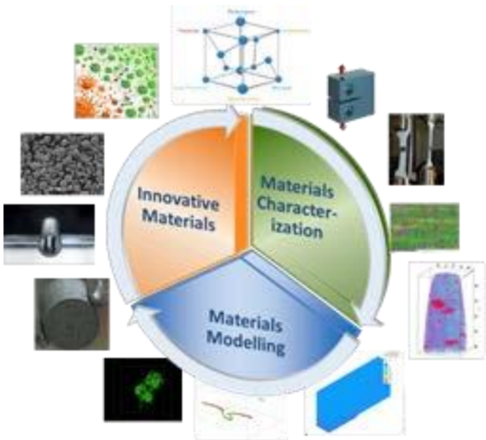
Why a Joint Programme on Nuclear Materials?

The goal of sustainability is common to all low-carbon energy sources. Sustainable nuclear energy systems combining fast reactors and fuel recycling facilities, denoted as Generation IV, can be built and allow the energy output from available resources to be substantially increased, while minimising high level radioactive waste through transmutation processes. These systems can thus potentially provide energy for many centuries to come. However, materials capable of withstanding extreme conditions like high temperature, prolonged irradiation, and chemically aggressive environments, need to be selected or developed and properly qualified. Some of these conditions are common to other high energy efficiency systems. Because of the pivotal importance of materials in view of sustainable nuclear and non-nuclear energy, a joint programme on nuclear materials finds its natural place within the EERA.

JP Nuclear Materials – visions and objectives

The objective of this EERA JP on Nuclear Materials is to improve safety and sustainability of Nuclear Energy by focusing on materials aspects:

- Better knowledge of materials behaviour under operating conditions, seeking predictive capability, to select the most suited materials and define safe design rules, especially allowing for radiation and temperature effects, while caring for compatibility with coolants.
- Development of innovative materials with superior capabilities, resistant to high temperature and aggressive environments.



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Joint Programme on Nuclear Materials Sub-programmes

Sub-programme 1: Materials for ESNII demonstrators and prototypes: the early ESNII (European Sustainable Nuclear Industrial Initiative) systems will rely on commercially available materials such as austenitic and ferritic/martensitic steels or nickel alloys that need to be qualified for the expected extreme conditions and a 60 years design life. A pre normative R&D programme for structural and clad materials has been initiated including updating of Design Codes for high temperature applications.

Sub-programme 2: Innovative high temperature resistant steels: The fuel cladding experiences the highest irradiation doses, thermal, mechanical and chemical stresses. These conditions require very high quality materials and outstanding materials performance, also in view of the role of fuel cladding as a safety barrier. ODS steels are considered the most promising fuel cladding candidate materials for the liquid metal cooled systems. Steels with good properties can also be produced optimising composition and thermomechanical treatments.

Sub-programme 3: Refractory materials: ceramic composites, cermets and metal-based alloys: ceramic composites (i.e. SiC/SiC) are the first option for the fuel cladding of the gas-cooled systems, where this component will operate at temperatures above 900°C, so conventional and ODS steels are not appropriate anymore. Recently, emerging ternary carbide composites (MAX phase-based cermets) have been also included for preliminary evaluations as promising erosion/corrosion resistant materials for the liquid metal cooled systems.

Sub-programme 4: Physical modelling and modelling-oriented experiments for structural materials: Modelling activities will provide knowledge, data and tools needed to interpret correctly and extrapolate the experimental results devoted to the qualification of materials and components. Physical phenomena related to the synergistic effect of irradiation and environment cannot be supposed to be linear. Incubation times or doses and thermally activated processes may determine the appearance of totally unexpected responses above a certain dose or temperature.

Sub-programme 5: Synthesis, irradiation and qualification of advanced fuels: Nuclear fuels are exposed to extremely severe operating conditions, including high temperatures, temperature gradients, damage due to neutrons and fission products, changing chemical composition and modified mechanical properties. The understanding of this plethora of effects is essential in the safety assessment of the fuels. Fuels for fast neutron reactors are the key focus.

Sub-programme 6: Physical modelling and separate effect experiments for fuels: The safety assessment of nuclear fuel requires a deep knowledge of the material properties of the fuel, and an even deeper understanding of the multitude of phenomena occurring during irradiation. These conditions are already severe under normal operation, but become even more acerbated during transients or severe accidents. The focus of the efforts lies in fast reactor fuels as selected for the fast neutron reactor systems considered in ESNII.