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Progress and Challenges in Structural and Functional Materials Development for Breeding Blanket in Korea

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The breeding blanket is one of the key components for the realization of fusion energy. It plays multiple roles, including tritium breeding for fuel self-sufficiency, heat extraction for power generation, and neutron and gamma-ray shielding for the protection of other reactor components. Reduced Activation Ferritic/Martensitic (RAFM) steel is the primary candidate for the structural material, and lithium-based ceramics are considered promising solid tritium breeder materials.

In Korea, the Advanced Reduced Activation Alloy (ARAA) has been developed by the Korea Institute of Fusion Energy (KFE) and the Korea Atomic Energy Research Institute (KAERI) since 2012. ARAA includes a small amount of zirconium to enhance impact and creep resistance. Approximately 6 tons of ARAA have been successfully fabricated on an industrial scale using Vacuum Induction Melting (VIM) and Vacuum Arc Remelting (VAR) processes. The physical, thermal, and mechanical properties of hot-rolled ARAA plates have been evaluated according to ASTM and EN ISO standards. The resulting database has been submitted to the RCC-MRx subcommittee for codification in the 2025 edition. Neutron irradiation testing and post-irradiation examination (PIE) of ARAA are currently underway using the HANARO research reactor and IMEF hot cell facilities.

For tritium breeder materials, a slurry droplet wetting method has been developed to fabricate Li_2TiO_3 and Li_4SiO_4 pebbles. An automated slurry dispensing system has also been established for mass production. The physical, thermal, mechanical, and thermomechanical properties of Li_2TiO_3 pebbles and pebble beds are being evaluated through domestic and international collaboration. Notably, neutron irradiation and tritium release tests are being conducted using the HINEG-CAS D-T neutron source and tritium handling facility at INEST in China under the Korea–China collaborative program.

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