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Multifunctional nanoceramic coatings for future generation nuclear systems

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Several breeding blanket concepts for the DEMO reactor employ the eutectic Pb–16Li as breeder material, namely Helium Cooled Lithium Lead (HCLL), Water Cooled Lithium Lead (WCLL) and Dual Coolant Lithium Lead (DCLL). These three concepts share, with different incidences, three major technological challenges: tritium containment, steel corrosion and magnetohydrodynamic drag. Here, we describe the ongoing work on multifunctional Al2O3 nanoceramic coatings grown by Pulsed Laser Deposition (PLD) and Atomic Layer Deposition (ALD) on T91 steel. In fact, these two techniques are complementary from the manufacturing point of view since the first can produce relatively thick (up to 10s of μms) high performance coatings, while the latter is capable of coating complex 3D objects with thin films (in the order of 100s of nms). Both coatings were tested as tritium permeation barriers with hydrogen at different temperature (from 350 to 650 ℃). Results collected in this way indicate an excellent behavior, with a permeation reduction factor (PRF) up to 10^5 for both PLD and ALD coatings. In the case of PLD grown Al2O3 coatings, these results have been shown to be maintained also in the case of deuterium under 2MeV electron irradiation. Moreover, the electrical conductivity of these dielectric coatings is shown to be extremely low even when subjected to irradiation. ALD coatings are being currently tested in these conditions. Finally, to evaluate the chemical compatibility of Al2O3 films in liquid eutectic Pb-16Li, PLD and ALD samples have been exposed to static corrosion tests up to 8000 hours. No corrosive attacks on the steel substrate are detected. In conclusion, alumina coatings deposited by PLD and ALD show great promise to tackle the major technological challenges associated to the BB concepts employing Pb-16Li as breeder materials.

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