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Nanoceramic Alumina Coatings for future nuclear reactors

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Among next generation nuclear systems, LFRs (Lead-cooled Fast Reactors) represent one of the most promising concepts. Ideally, lead can solve most of the issues associated with other types of coolants, such as sodium (strong chemical reactivity) or lead-bismuth eutectic (activation under irradiation)[1]. On the other hand, one of the main drawbacks of lead is its aggressiveness towards structural steels, especially above 500-550°C[2]. In this framework, ceramic coatings are being investigated for protecting steels[3]. Here, fully dense and compact Al2O3 coatings are grown at room temperature by Pulsed Laser Deposition. The technique has been developed and optimized to deposit on both plane and cylindrical geometries. Mechanical characterizations of deposited films reveal that the coatings attain an unusual combination of metal-like mechanical properties (E=195±9 GPa and v=0,29±0,02), ceramic hardness (H=10±1 GPa), and strong interfacial bonding[4]. The similarity of mechanical properties with steels avoids stress concentrations, reducing the risk of cracking or delamination. This observation is confirmed by thermal cycling, creep experiments and burst tests conducted on coated 316L tubes and 1515Ti cylinders. These materials are of practical interest for next generation nuclear systems. Finally, corrosion aspects are examined by short- (500 hours) and mid-term (2000 hours) exposure of samples to stagnant lead at 600°C in monitored atmosphere, with different oxygen contents. Post-test analyses reveal no signs of corrosion, irrespective of the oxygen content in the liquid metal. In conclusion, PLD-grown Al2O3 coatings are a promising candidate for protecting fuel cladding from corrosion in LFRs. [1] Generation IV International Forum, Overview of GIF and Generation IV, 2002. [2] G. Müller et al., J NUCL MATER, 278 (2000) 85–95. [3] F. Garcia Ferré et al., CORROS SCI, 77 (2013) 375-378. [4] F. Garcia Ferré et al., ACTA MATER, 61 (2013) 2662-2670.

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