Cr and Polycrystalline Diamond Coatings for Accident Tolerant Nuclear Fuel Tubes

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Abstract

The essence of this work is to show a possibility to increase the safety of nuclear reactors and extend the life of nuclear fuel by reduction the corrosion of the zirconium fuel tubes by double layer coating consisting of polycrystalline diamond (PCD) and magnetron sputtered Cr. In double layer coating the water permeable 500 nm thick polycrystalline diamond layer consisted of hard diamond grains (<70%) and soft graphitic carbon phase. The Cr coating was 2-3 μm thick. We used Cr layer as bottom and PCD as top coating and also Cr layer as top and PCD as bottom coating of ZIRLO fuel tube. Coated and bare ZIRLO fuel cladding tubes were subjected to hot steam/water tests for 30 min at 900°C and for 40 min at 1000°C. The hot steam processed double layer coated ZIRLO oxidation was lower than uncoated hot steam processed ZIRLO. Surprisingly, the hot steam processed Cr coated ZIRLO oxidation was even lower than the double layer coated hot steam processed ZIRLO when PCD layer was bottom layer. On the contrary, when ZIRLO was coated by Cr layer as bottom and PCD layer as top layer then its accidental oxidation was lowest of all samples we have ever tested. Raman spectroscopy, scanning electron microscopy, X-ray diffraction and energy-dispersive spectroscopy were performed to study relevant processes and states affecting coated ZIRLO hot steam corrosion.

Keywords: nuclear fuel tubes corrosion, nanodiamond layer; chemical vapor deposition, Cr magnetron sputtering;

IEECP'22, July 21-22, 2022, Oxford, United Kingdom