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Development options for the TUM PVD Zr application process for monolithic U-Mo fuel

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ABSTRACT

Over the past years, TUM has developed a PVD Zr interdiffusion barrier application process for monolithic U-Mo fuels. This process has been successfully used to produce 7 LEU mini-size foils for the EMPIrE irradiation test, scheduled later this year.

The properties of this barrier, like adherence, hardness and stress, strongly depend on the energy available to the Zr adatoms forming the layer. This energy originates from the kinetic energy of Zr atoms, Ar ions/atoms and electrons as well as from the temperature of the U-Mo substrate. It can thus be either controlled by an increased charged particle bombardment or by an additional substrate heating system. The former has been used for the production of the EMPIrE test plates. For the upscaling and industrialization of the process, TUM currently investigates the possibility to implement the industrially established substrate heating approach.

At elevated temperatures a phase decomposition of the U-Mo γ phase as well as a U-Mo-Zr interdiffusion process can occur. Both effects need to be limited to ensure the successful production and irradiation performance. Such effects are known from different production processes, like Hot Isostatic Pressing and Co-Rolling. Therefore, an experiment has been performed whether this behavior can be transferred to PVD coating processes, or if the predictions and dependencies must be adapted.

Within this study, a number of U-Mo samples has been Zr-coated with different heating/cooling rates, process temperatures and coating rates. For each sample, the overall U-Mo phase decomposition has been measured by neutron diffraction. The U-Mo-Zr interdiffusion process has been destructively analyzed with SEM and EDX and diffusion rates have been compared with literature values.