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Calculating the release fraction of W tendrils into the plasma using polymeric reptation theory

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Prolonged exposure of tungsten surfaces to magnetic fusion plasma environments results in the formation of a 'fuzz', a nano-structured surface layer with about 2-3 microns in thickness that forms at temperatures above 1000 K. The fuzz can be described as a microstructure of tangled tendrils attached to a tungsten substrate and submerged in a hot fluid. This is not unlike polymeric chains attaching to an inorganic substrate and embedded in a fluid solvent. A theory to describe the dynamics of such systems exists, known as `reptation' theory, which furnishes expressions for the strength of such elongated chains due to interactions with other chains and with the fluid.

In this work, we adapt reptation theory to fuzz microstructures and calculate the stiffness of the system and relate it to a probability of detachment and emission, leading to plasma contamination.