IPP INSTITUTE OF PLASMA PHYSICS OF THE CZECH ACADEMY OF SCIENCES

TUNGSTEN SCARIFICATION CONCEPT

hilase

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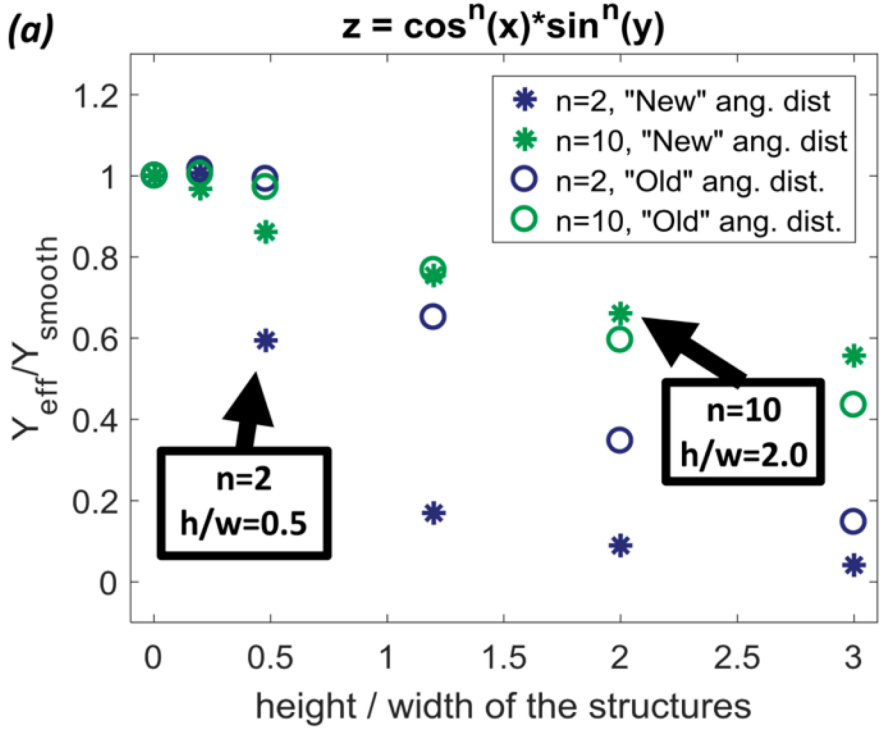
Motivation

- Tungsten impurity is a major threat for future reactors – efficient cooler for fusion-relevant plasma core temperatures. It can prevent reaching desired values of Q or e.g. high confinement mode
- Sputtering from plasma-wetted areas (e.g. divertor strike points) is often not the main problem - W gets ionized close to the surface and then transported back onto the PFC
- Tungsten PFCs with poor contact with plasma (low T_e, n_e) allow the neutral W to travel far before it gets ionized -> can be transported in the confined plasma. This was identified e.g. for JET [Kumpulaien NME 2022], where energetic neutrals originating from CX collisions were a major driver of the tungsten impurity. Simulations for CEFTR also suggest that first wall will be the main source of tungsten [Xu PST 2025]
- Most PFCs are currently optimised for power loading – small gaps, bevels etc. However the components with poor plasma contact may be instead optimized for low sputtering
- Recent paper [Eksaeva NME 2019] suggest that rough surface can reduce sputtering by a factor 4-6x!



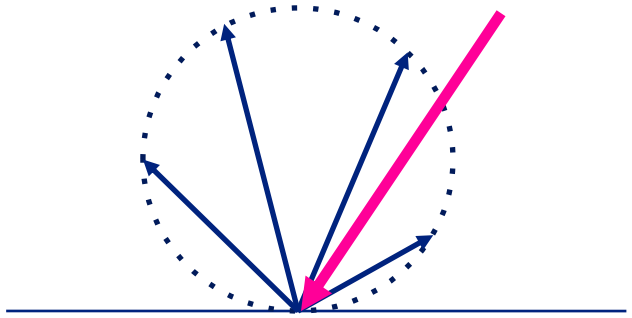
[Eksaeva NME 2019]

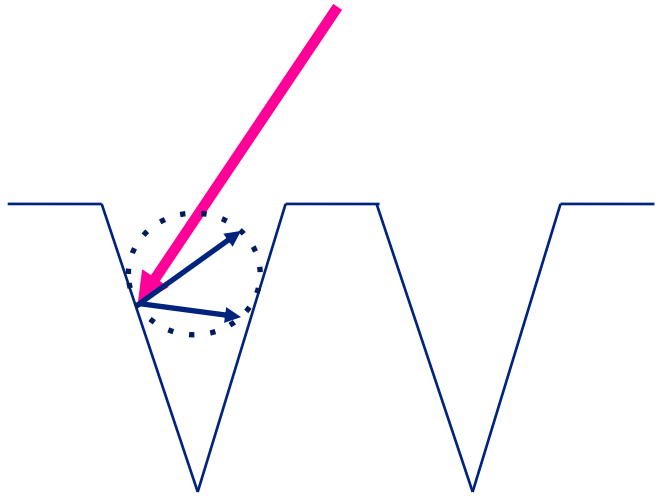
- Erosion measurements at AUG reported 3-7x smaller tungsten erosion for rough surfaces [Hakola PSCR 2014]

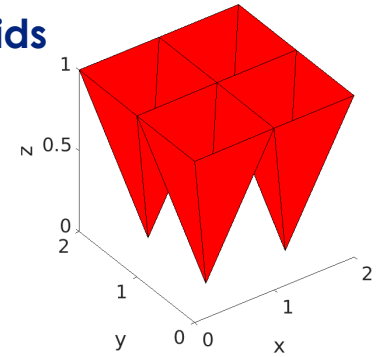
Plan for 2026

The idea: use **tungsten surface with manufactured micro-structure** to reduce the tungsten sputtering both by plasma ions and CX neutrals! -> **tungsten scarification**

This surface can have many forms, a simple one is a **grid of inverse pyramids**





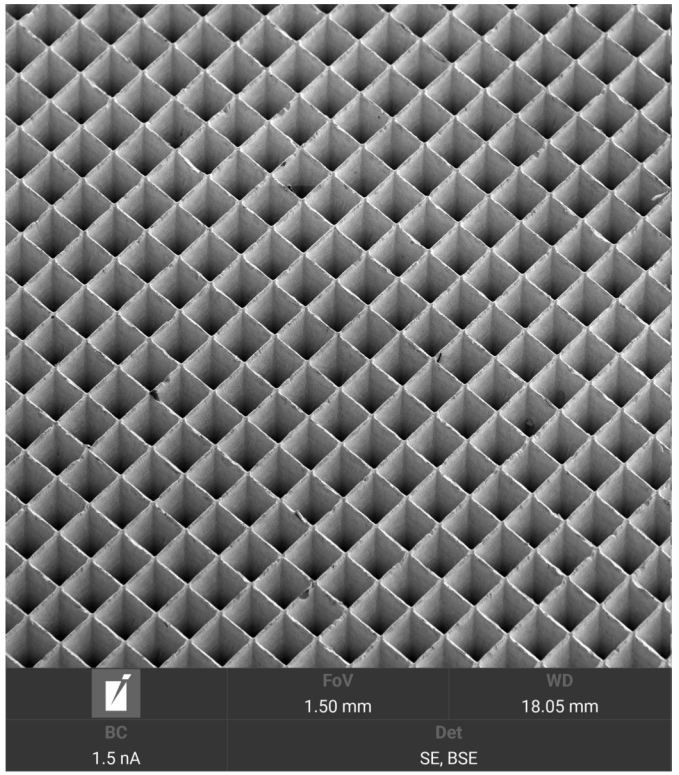


Many of the sputtered W atoms should hit the opposing surface of the pyramide instead of escaping into the plasma.

For small enough scale (~ 0.1 mm) the **heat diffusion in tungsten** should prevent overheating of the edges

ERO 2.0 modelling for COMPASS-U parameters: reduction of tungsten source by factor **2**-40x (depends on velocity distr. of W atoms

Plan for 2026: compare sputtering from scarified surface against flat surface in Magnum PSI



First prototype sample 10x10 mm with pyramids 0.1 mm wide and 0.2 mm deep produced at **HiLASE** facility using laser Indylit 20 SH (100 kHz, 400 fs, 515 nm, 1.4 W) – 4h 20 min.