WP PWIE SPA3 (2022): KIPT
D004: Investigation of advanced materials under ELM-like/ disruption transient loading and subsequent analysis

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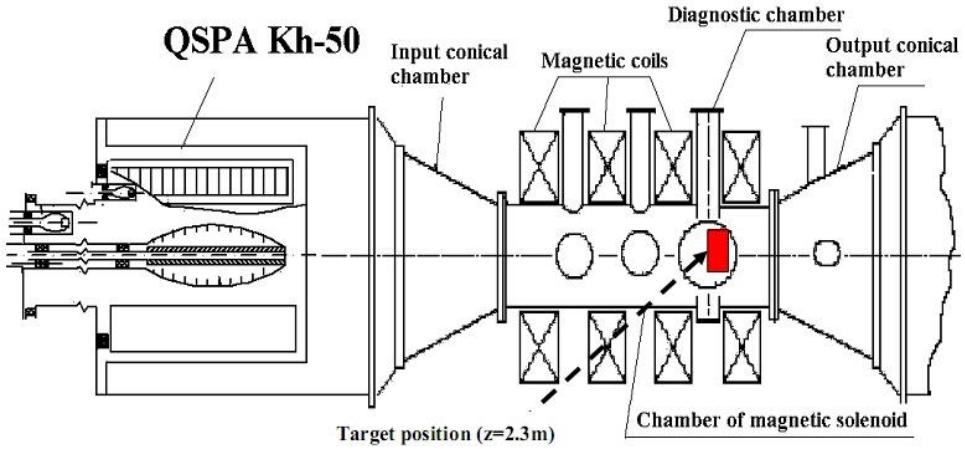
PWIE-SP A.A3.T-T002: Advanced Materials under thermo-mechanical and plasma loads (2022)						
ID	Title	RU	Del. Owner	PM 50%	QSPA	
					PM 40%	Eq./OGS 40%
PWIE-SP A.A3.T-T002-D004	Investigation of advanced materials under ELM-like/disruption transient loading and subsequent analysis (KIPT)	KIPT	Igor Garkusha	15	6.99	5 days

Tasks planed for 2022:

❖QSPA plasma qualification of new materials (WPMAT) and components (WP DIV) for DEMO: Thermal shock and plasma synergistic loading to advanced materials.

❖Target exposures in several plasma devices to study the interplay of recovery, recrystallization, plasma and ELM-like loading on surface cracking and fatigue (FZJ, KIPT, DIFFER)

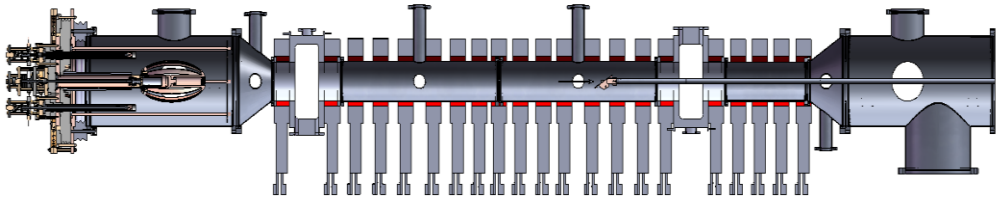
SPA3: Experimental facilities: QSPA Kh-50; QSPA-M



Plasma energy density	0.1–2.2 MJ/m^2
Plasma load duration	0.25 ms
Diameter of plasma stream	15 cm

V A Makhlai et al *2020 Phys. Scr. T171, 014047*

QSPA-M



Plasma energy density	0.1-1 MJ/m^2
Plasma load duration	0.1 ms
External magnetic field	0.8 T
Diameter of plasma stream	6 cm

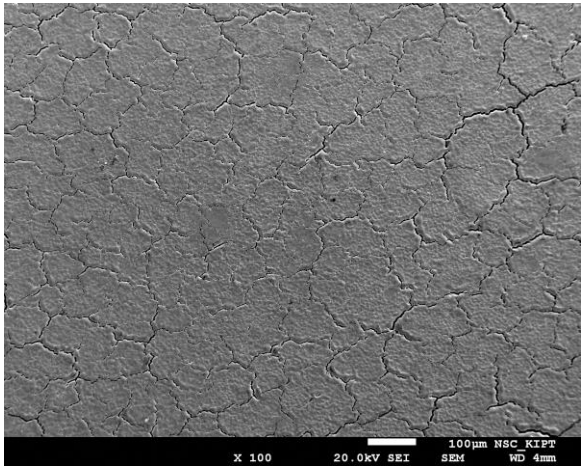
Diagnostics

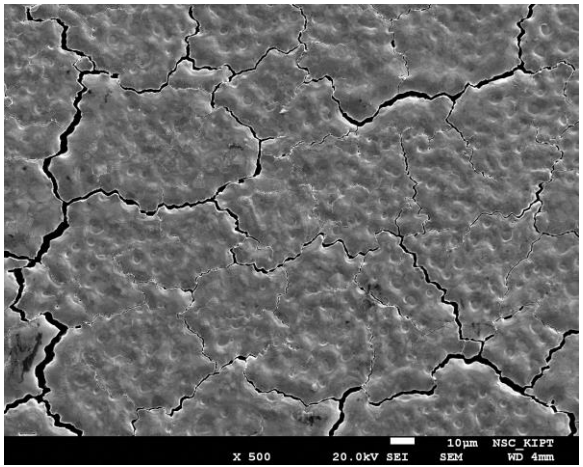
- ❖Calorimetry
- ❖Optical emission spectroscopy
- ❖High-speed digital camera PCO AG

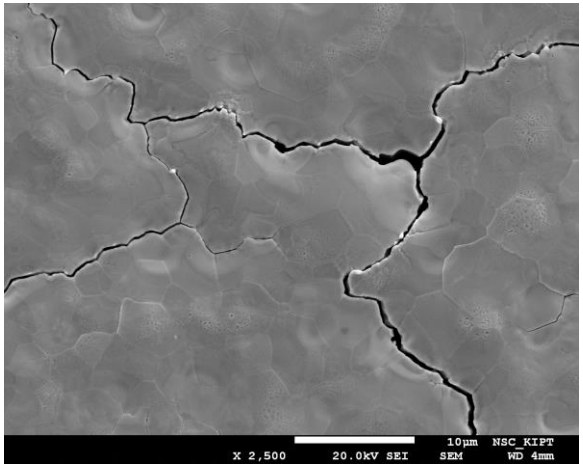
I.E. Garkusha et al 2017 Nucl. Fusion 57, 116011;
I.E. Garkusha et al 2019 Nucl. Fusion 59, 086023

SPA3: IGP W material with transversal grain

- The 12 polished samples of the IGP W material with transversal grain orientation were provided by Marius Wirtz as link between WP MAT at august 2021.

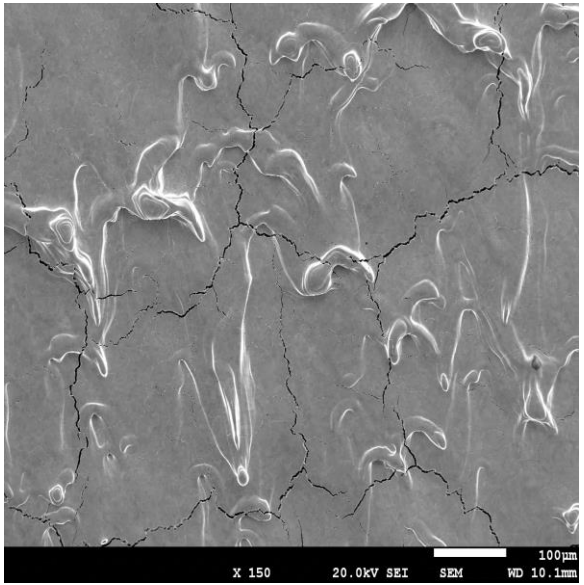


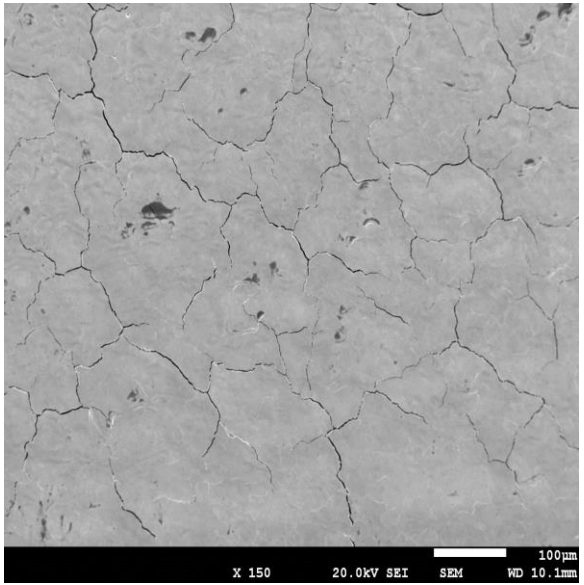


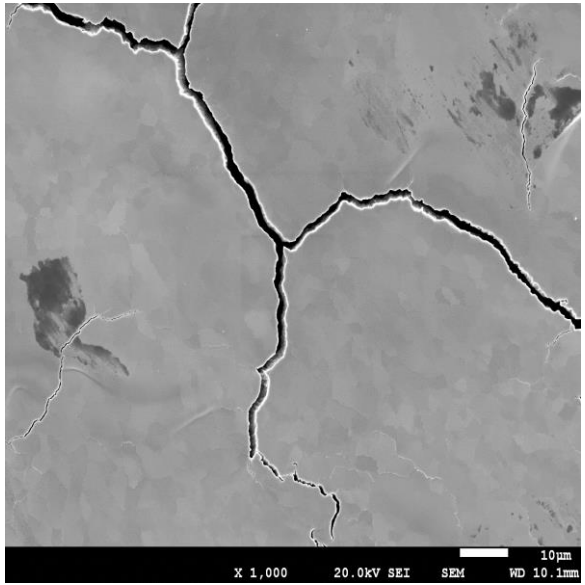


T tungsten demonstrated the best resistance to applied QSPA plasma heat loads.

SPA3: IGP W material with transversal grain

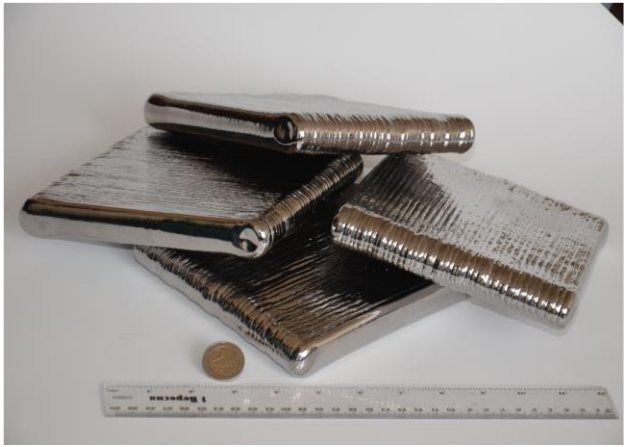




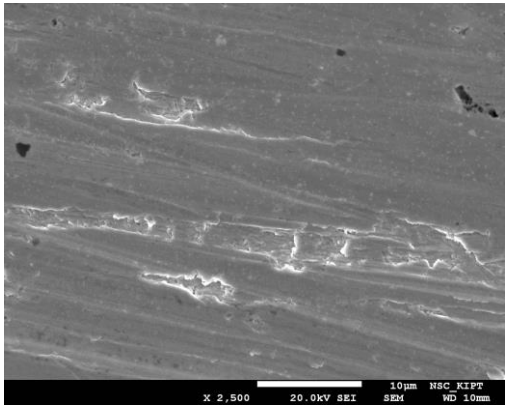


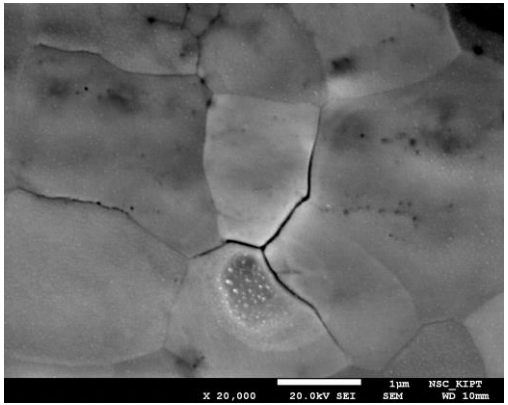
- **Helium exposure; MPC Short pulse duration** (τ_{pulse}=20 µs); T_{base} = RT
- **Resolidified layer**
- **Melt motion**
- **Macro and Micro-crack networks**

Surface heat load is **above the tungsten melting threshold**



- Samples of large profiled tungsten single crystals (up to $20 \times 170 \times 160$ mm^3) produced by means of plasma-induction growing technology at E.O. Paton Electric Welding Institute, Kyiv Ukraine were irradiated by 10 plasma pulses in the end of 2021.
- Heat loads 0.75 MJ/m^2, i.e. above W melting threshold.
- Base temperature was $T_{base} = 400°C$



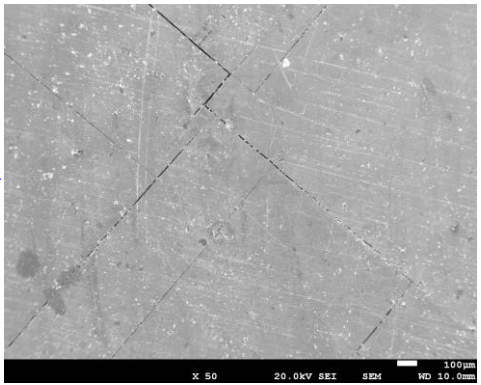


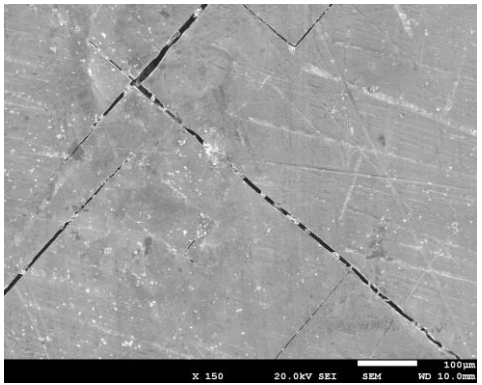
- Cracks, separation of particles are observed on the exposed surfaces

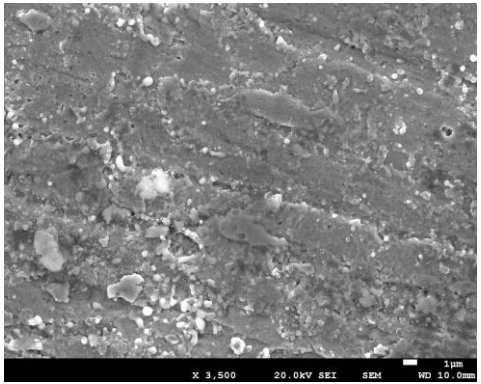
SEM images: sample after plasma irradiation

Base temperature was T_{base} = RT

QSPA M heat load near the W melting threshold





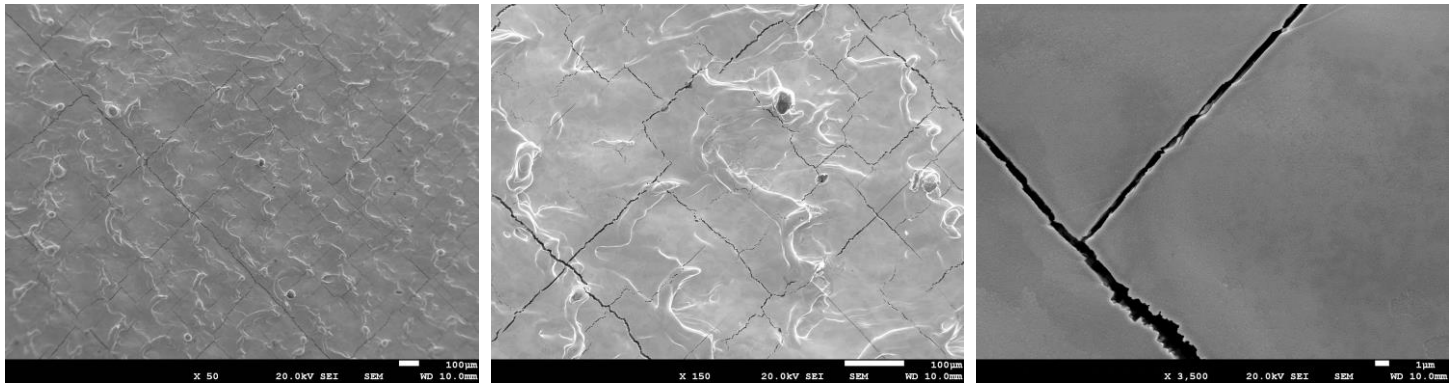


- Macro and Micro crack networks
- Surface modifications

SEM images: samples after plasma irradiation

Base temperature was T_{base} = RT

MPC heat load above the W melting threshold

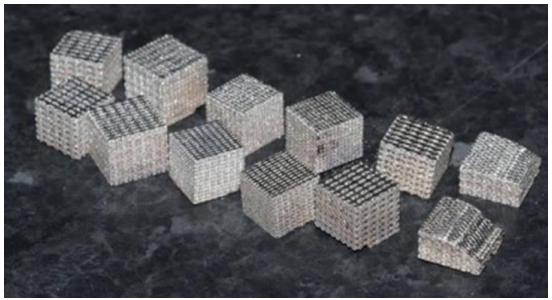


Tungsten sample was irradiated by 10 MPC pulses (τ_{pulse}=20 μs ; T_{base} = RT; the working gas is Helium).
Surface heat load is **above the tungsten melting threshold**

- Macro and Micro crack networks
- Melt motion

Latticing AM W/WTa samples (WP DIV) exposed within QSPA Kh-50

	Sample origin
Lattice W Ta L6 Not polished	CCFEx4
	CCFEx4
	CCFEx4
Lattice W Ta L6 Polished	CCFEx4
	CCFEx4
	CCFEx4
Lattice W L6 Polished	IPPx4
Solid W Not polished	IPPx2, CCFEx2
	IPPx2, CCFEx2



- SEM images was received for all exposed samples
- Other Post-mortem analyses will be performed in CCFE (delay due to COVID influence)

- Only first results for testing of Advanced Materials have been obtained.
- Advanced Materials should be further tested under different loadings later (incl. different gases mixtures, pulses duration, number of pulses, synergetic loads, etc.)
- Experiments were stopped in the end of February 2022.
- Deliverables will shifted to 2023