

Tungsten PFC Development & Testing

- Overview of Tungsten Research in Korea -



IEA FM Tungsten Meeting , 12 Oct. 2015, Aachen

Hyoung Chan Kim @NFRI

Contents

1

R&D for Tungsten Plasma Facing Component

2

Tungsten PFC mock-up fabrication

3

High heat flux test of the PFC mock-up

4

Tungsten Experiment in KSTAR

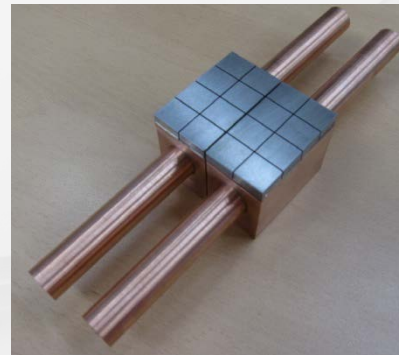


Tungsten Plasma Facing Component

- R&D for Tungsten PFC
 - ✓ Development of Tungsten bonding technology
 - ✓ Design and optimization of Tungsten PFC
 - ✓ Study on damage, lifetime of Tungsten PFC
 - ✓ Material test & surface morphology
 - ✓ Heat load analysis on Tungsten tiles
 - ✓ Fuel retention and its removal
 - ✓ Investigation of Plasma-Wall Interaction
- Fabrication of Tungsten PFC



Brazed flat tile sample



Flat type HIP mock-up

Development of Tungsten PFC mock-up

- Tungsten : W >99.94%, density >19.1 g/cm³, Hot rolled, ASTM B760, ITER grade
 - CuCrZr : Cu(bal) Cr(0.6-0.9) Zr(0.07-0.15), ITER grade
 - OFHC-Cu(interlayer) : C10200 (O <10 ppm) – interlayer to mitigate residual stress
 - Filler : Ni(9.5) Cu(52.5) Mn(38), plate type, 0.05 mm in thickness, liquidus 925 °C – silver free, high melting point for hot brazing
- Shear strength test – ASTM D5379, D905



A: 50 g/cm²



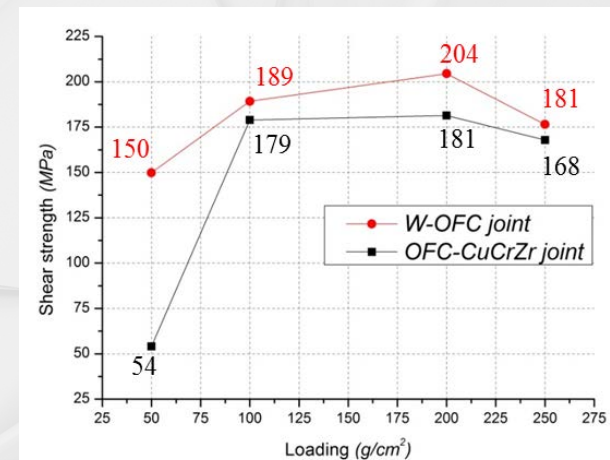
B: 100 g/cm²



C: 200 g/cm²



Result of shear test on samples brazed with various loading pressures



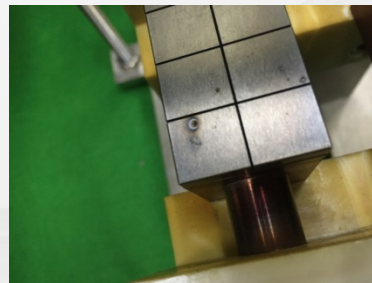
High Heat Flux Test of Tungsten PFC

- KoHLT-EB (Korea Heat Load Test facility-Electron Beam) in KAERI
 - : scanning on whole area of mockup with electron beam of 10 mm in diameter & 10 kHz in frequency
- Results of high heat flux test on Tungsten brazed PFC mock-ups

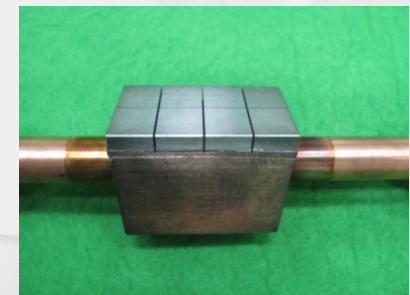
Mockup	Coolant (inlet)	Absorbed heat flux [MW/m ²]	No. of cycles	On/off time [sec]	failure	Surface temp. [°C]	Tungsten temp. [°C]	CuCrZr temp. [°C]
#2(D)	Water P = 0.35 MPa \dot{m} = 0.35 kg/s T = 18 °C	~ 5	2,000	20/20	No	520	384	243
#3(E)		~ 5	1,000	20/20	No	-	415	243
#4(F)		~ 5	1,000	20/20	No	471	369	242



Electron beam scanning on mock-up



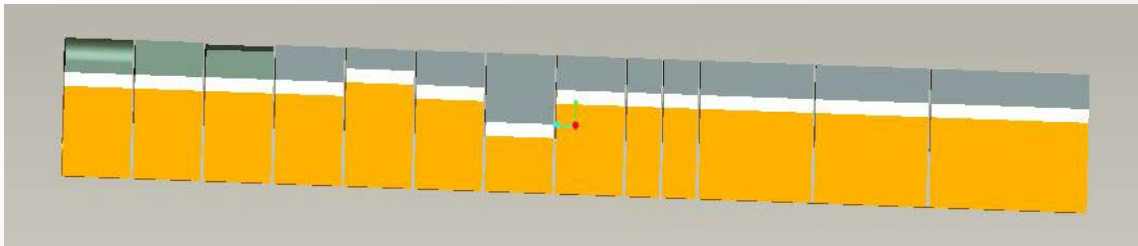
Top view of mock-up #F



Top view of mock-up #D

Testing of Tungsten PFC in KSTAR (1/2)

- Testing of Tungsten PFC in KSTAR
 - ✓ Leading edge power loading experiments were performed in 2014 & 2015 KSTAR campaign
 - Trapezoidal, ITER Base, flat type blocks with +0.3 mm, 0 mm, -0.3 mm misalignment
 - Leading edges with 2 mm, 1 mm, 0.6 mm, 0.3 mm misalignment
 - ✓ Exposure of Tungsten samples at Divertor (outer strike point) using vertical manipulator & divertor plasma simulator
 - Manufacturing of test block assembly
 - Block shape
 - Tungsten thickness
 - Width of Tungsten
 - Chamfer, double chamfer, rounded design
 - Leading edge experiment in Divertor region



Installed Tungsten tiles along Divertor IR line of sight

Testing of Tungsten PFC in KSTAR (2/2)

- Analysis of thermal response of Tungsten mono-blocks with leading edges is ongoing

- ✓ Deposited heat flux during standard H-mode (strike point sweeping) in KSTAR is about $3\text{--}5\text{ MW/m}^2$
- ✓ Exposed leading edges show some roughening in SEM pictures, but not that severe (No melting observed)

● Inter-ELM heat load

