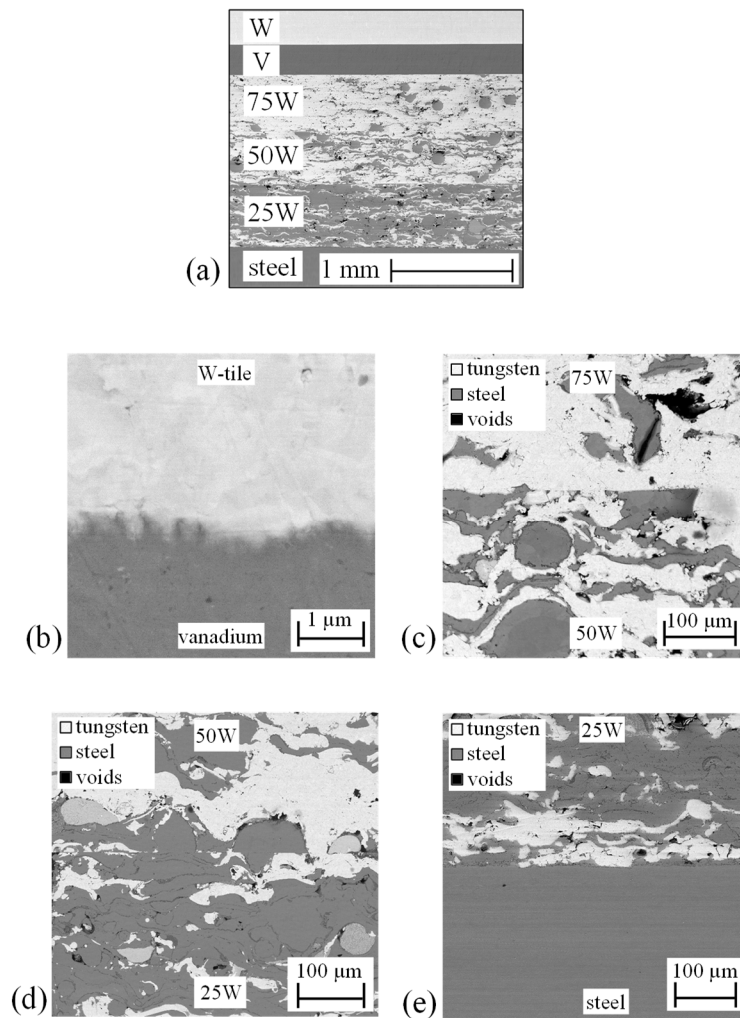
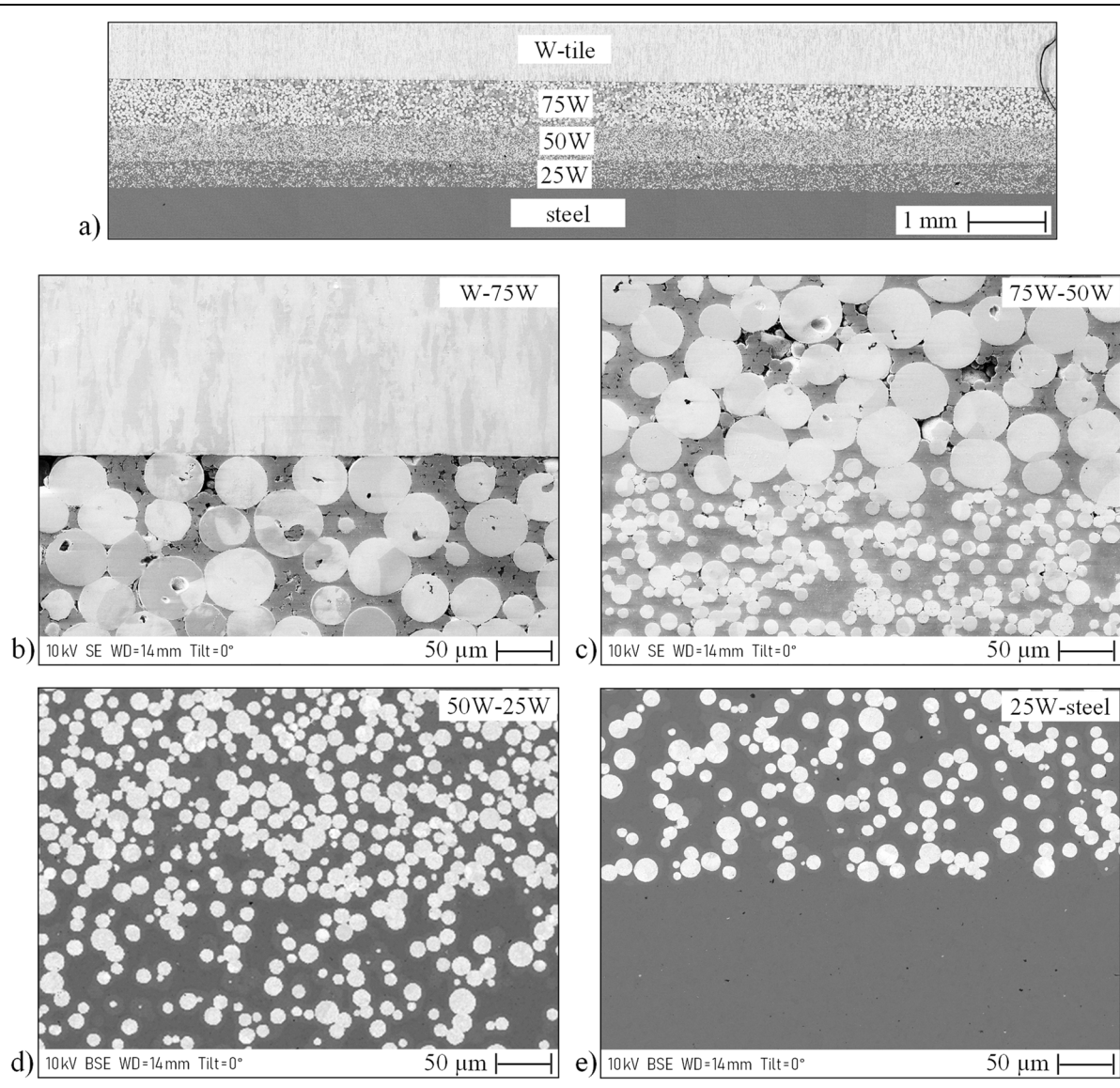


# High Heat Flux Testing of Various W-Steel Joining Concepts for the First Wall

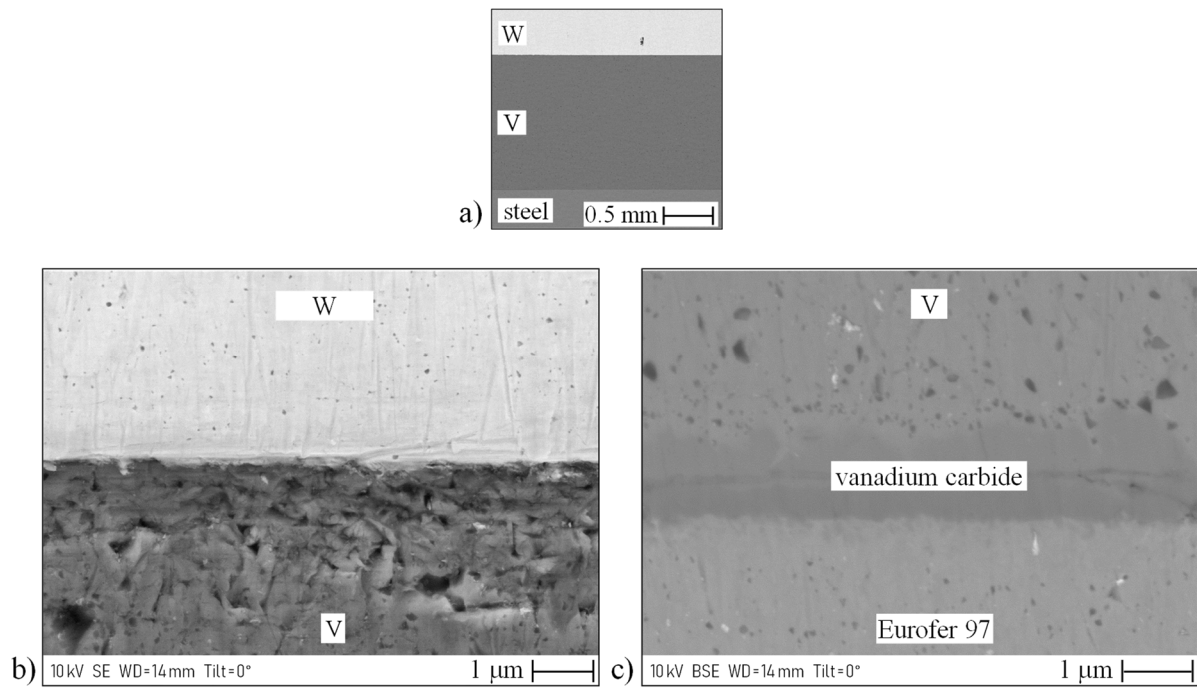
Comprehensive SEM micrographs of the joints



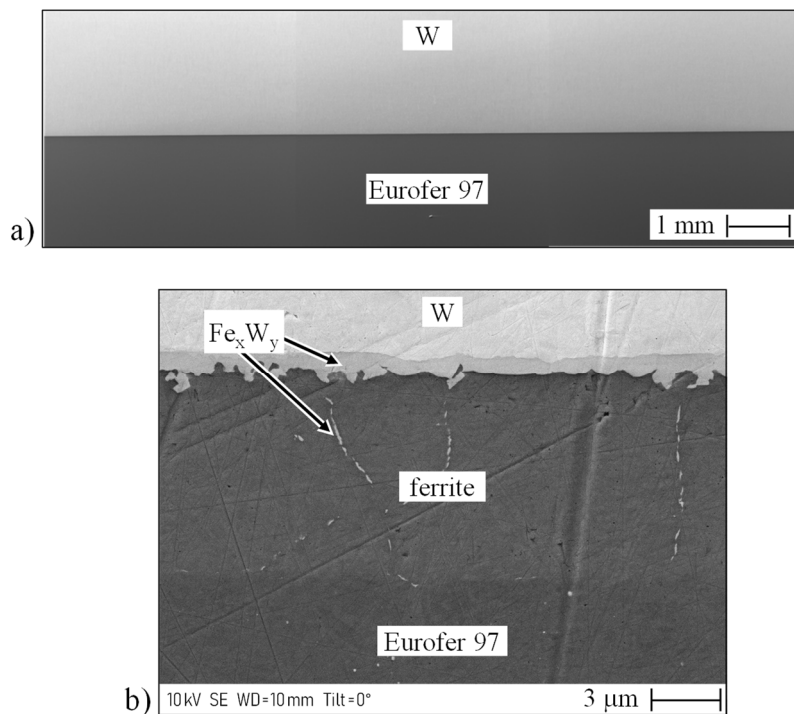
**Figure S1** a) Cross-sectional overview of FGM-APS joint; showing the following bond seams between: b) W-tile and V-filler, c) 75W and 50W, d) 50W and 25W, and e) 25W and steel (Note: Micrographs taken from the literature: V. Ganesh et al., Manufacturing of W-steel joint using plasma sprayed graded W/steel-interlayer with current assisted diffusion bonding, Fusion Eng. Des. 172 (2021) 112896).



**Figure S2** a) Cross-sectional overview of FGM-SPS joint; showing the following: b) bond seam between W-tile and 75W, c) transition between 75W and 50W, d) transition between 75W and 50W, and e) bond seam between 25W and steel

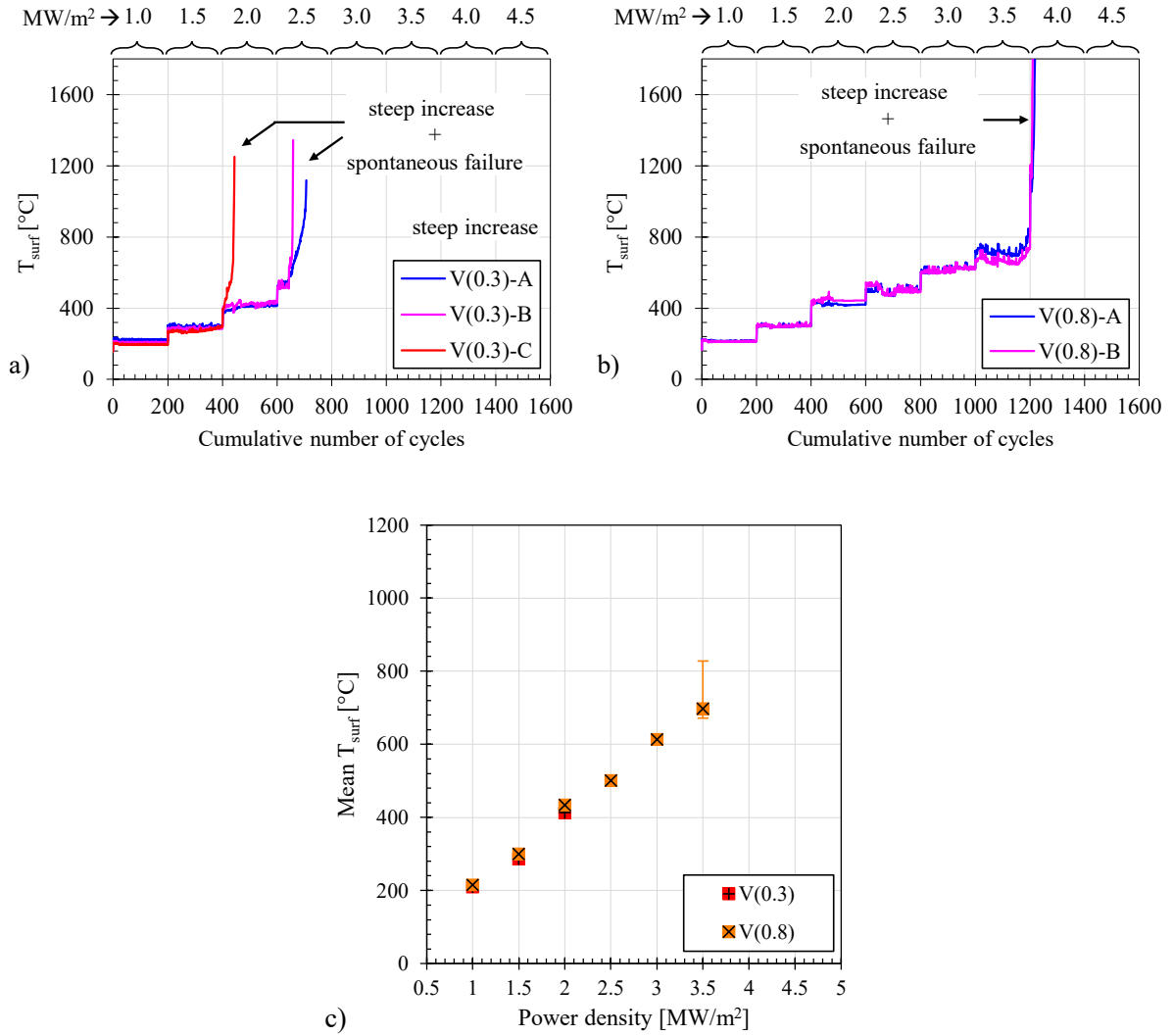


**Figure S3** a) Cross-sectional overview of V(1.5) joint, b) Interface between W-tile and V (Note: the scratch marks coming from the grind-polishing in V should be ignored), c) Interface between V and steel forming a thin vanadium carbide layer detected by energy-dispersive X-ray spectroscopy



**Figure S4** a) Cross-sectional overview of Direct joint, b) Interface between W-tile and Eurofer 97 showing the presence of 1 μm thick Fe<sub>x</sub>W<sub>y</sub> intermetallic phase and below it a ferritic phase. This ferritic phase is formed due to the diffusion of W into steel, below this ferritic phase is the parent Eurofer 97 steel material. (More information can be found in a similar study conducted by T. Hirose et al., *Joining technologies of reduced activation ferritic/martensitic steel for blanket fabrication*, *Fusion Eng. Des.* 81 (2006) 645–651.)

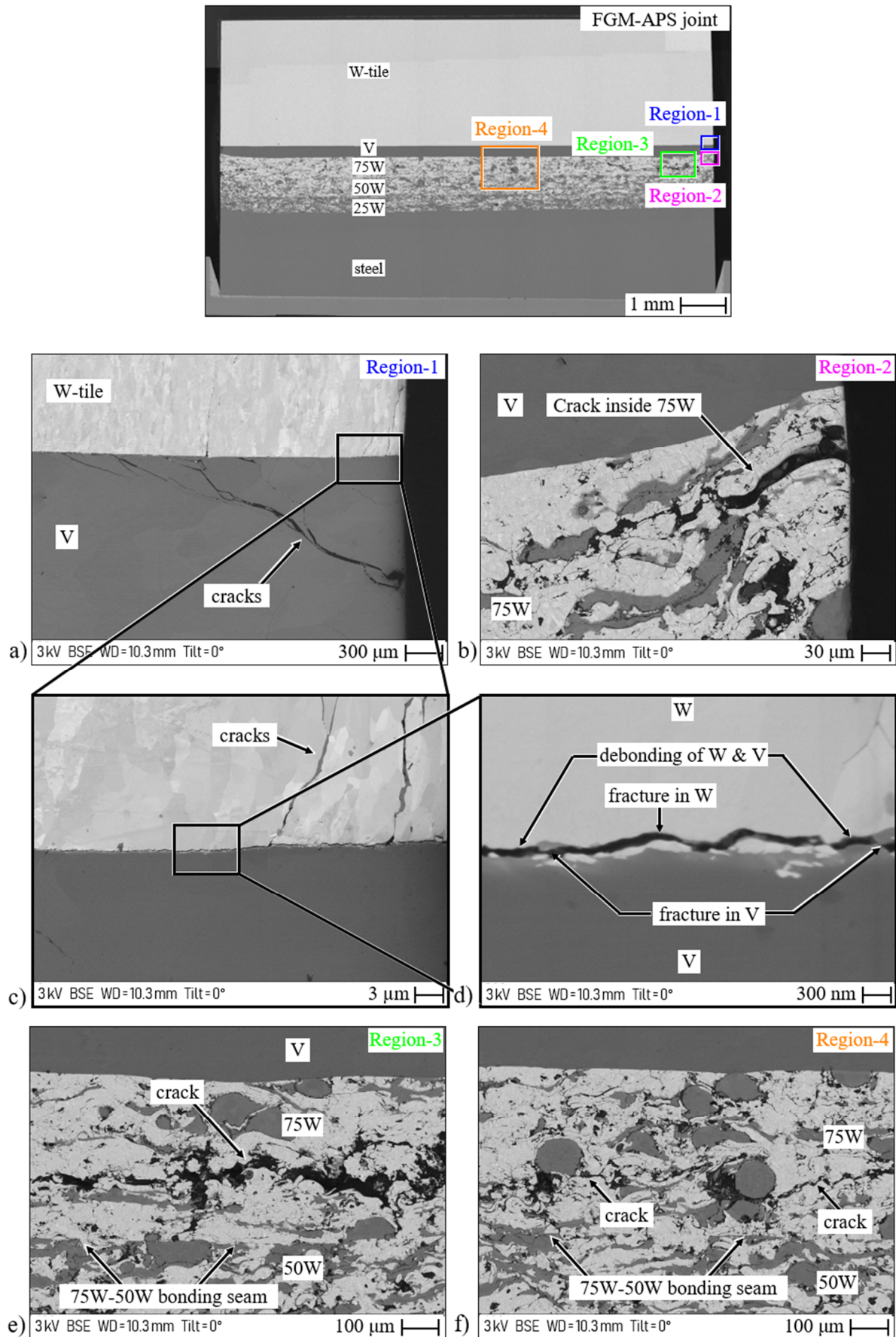
## Performance and lifetime of V(0.3) and V(0.8) joints



**Figure S5** a) History of steady-state surface temperature of W-tile for V(0.3) joint; all joints failed spontaneously between 2–2.5 MW/m² loading, b) History of steady-state surface temperature of W-tile for V(0.8) joint; all joints failed at the end of 3.5 MW/m² loading, c) Mean surface temperature of W-tile with respect to various power density

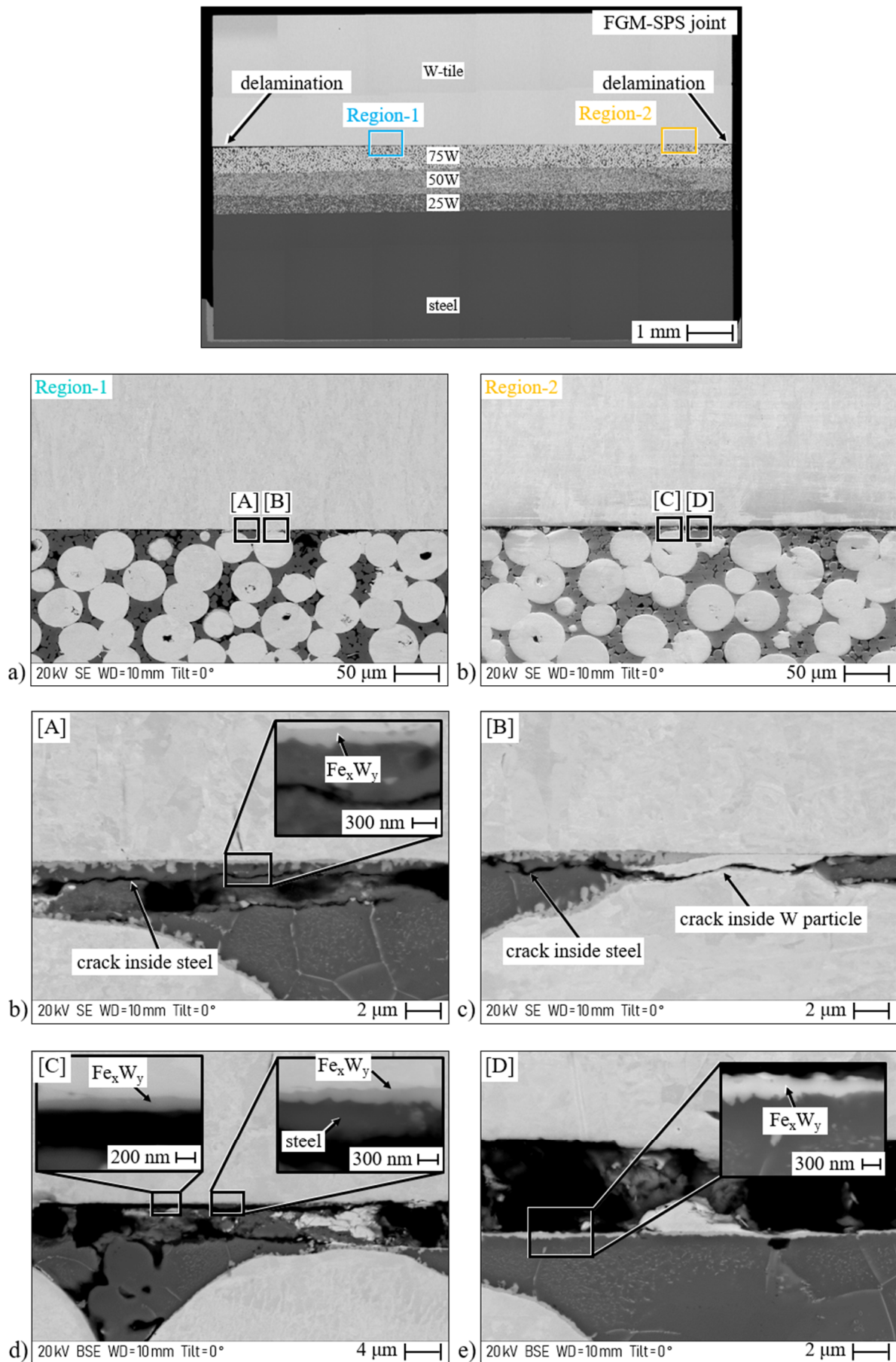


## Comprehensive post-mortem analysis of FGM-APS joint



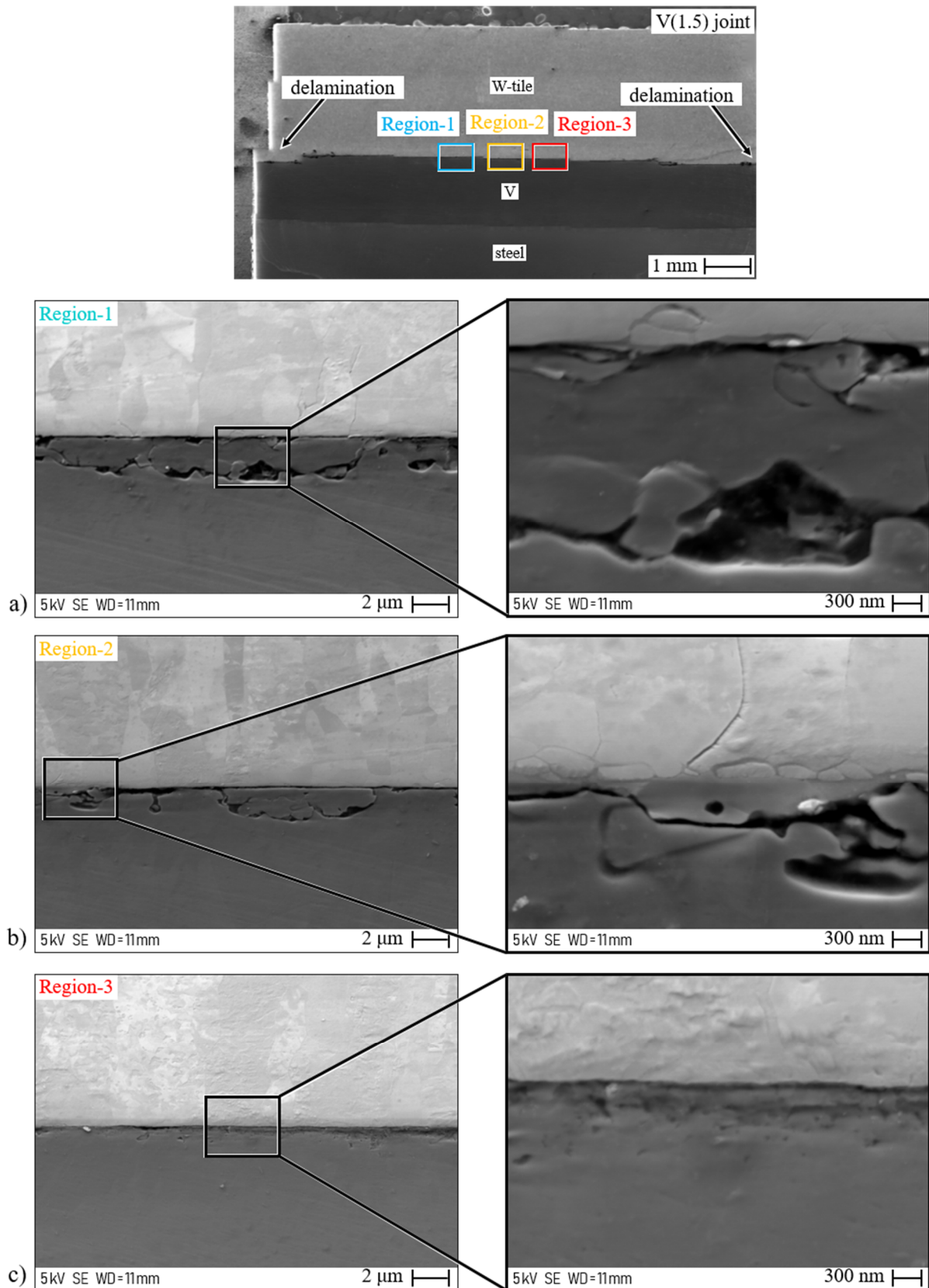
**Figure S6** Cross-sectional images of failed FGM-APS joint; a), c), d) Failure of bond seam between W and V-filler. b) Macrocracks in 75W at the edge; e), f) Macrocracks in 75W at the centre of joint

## Comprehensive post-mortem analysis of FGM-SPS joint



**Figure S7** Cross-sectional images of failed FGM-SPS joint with failure at the bond seam between W-tile and 75W layer incorporated by microscopic failures shown in a) to e)

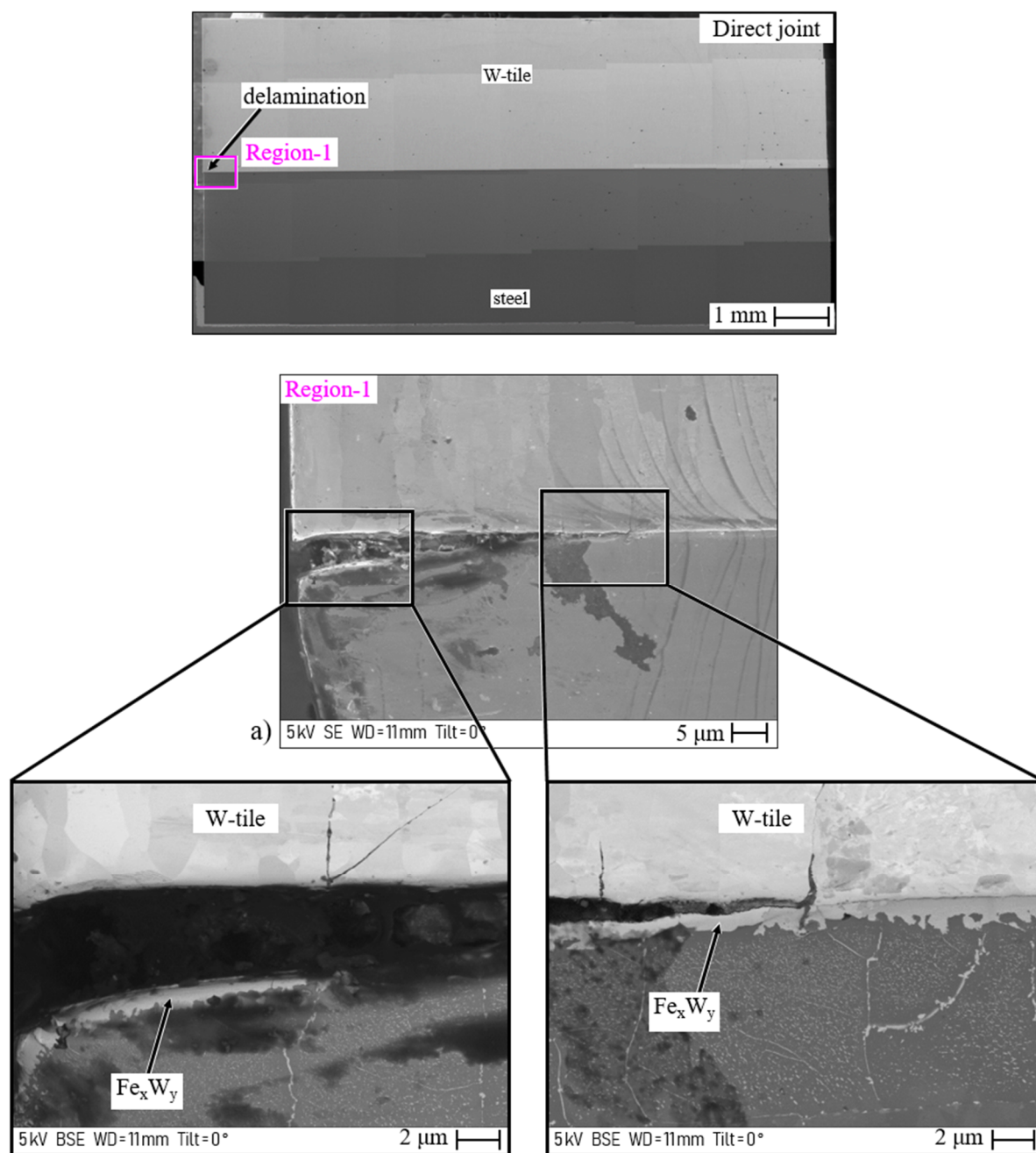
## Comprehensive post-mortem analysis of V(1.5) joint



**Figure S8** Cross-sectional images of failed FGM-SPS joint with failure at the bond seam between W-tile and V shown in three regions; the fracture mainly occurs within the V layer close to the bond seam as seen in a), b) and c)



## Comprehensive post-mortem analysis of Direct joint



**Figure S9** Cross-sectional images of failed Direct joint with failure at the bond seam between W-tile and steel starting at the edge of the joint