Mechanical properties of different refractory materials for nuclear fusion applications

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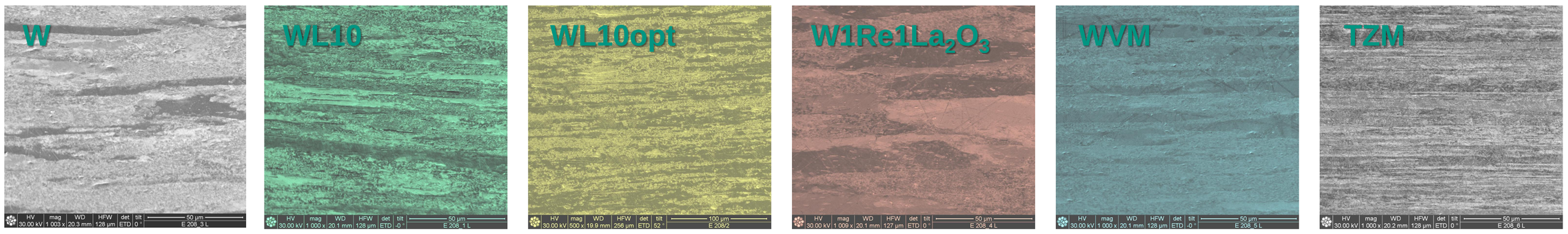


Fig. 1: Microstructure of the different rod materials (longitudinal cross-sections).

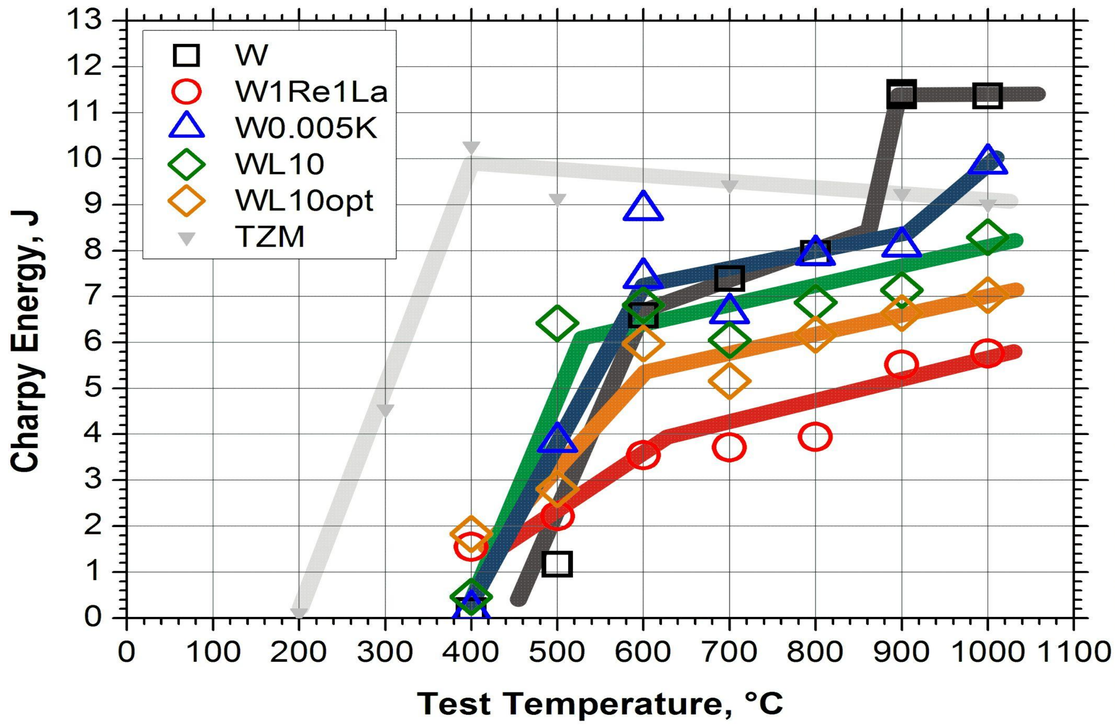


Fig. 2: Charpy test results of the rod materials. Between 400 °C and 600 °C there is a transition from brittle to cleavage fracture. Only pure tungsten and WVM shows a second transition at about 900 °C to ductile fracture.

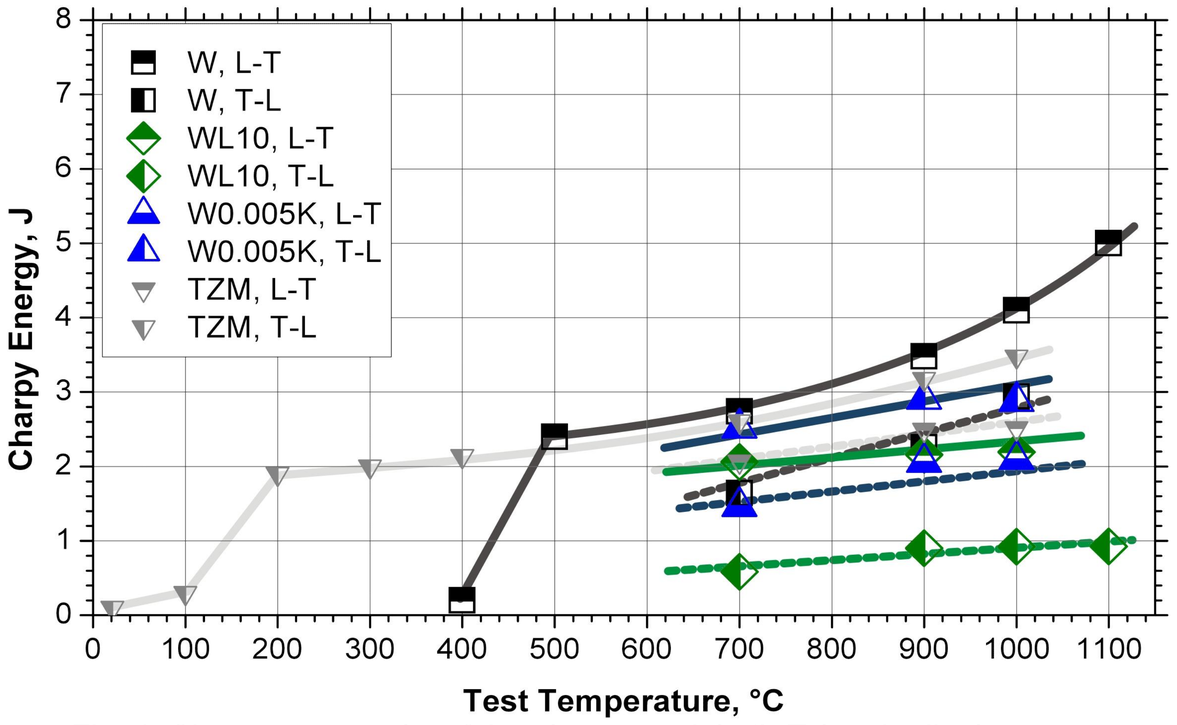


Fig. 4: Charpy test results of the plate materials (L-T: longitudinal, T-L: transverse to rolling direction).

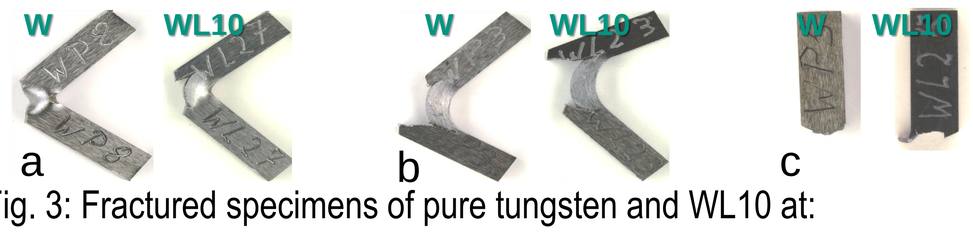


Fig. 3: Fractured specimens of pure tungsten and WL10 at: (a) 900 °C, (b) 600 °C, and (c) 400 °C.

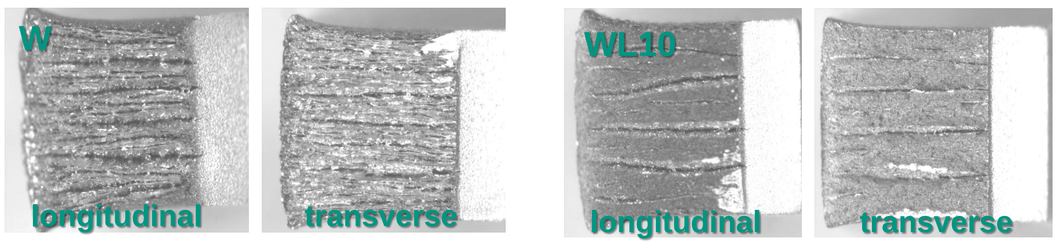


Fig. 6: At 900 °C delaminated fracture surfaces of typical plate specimens.

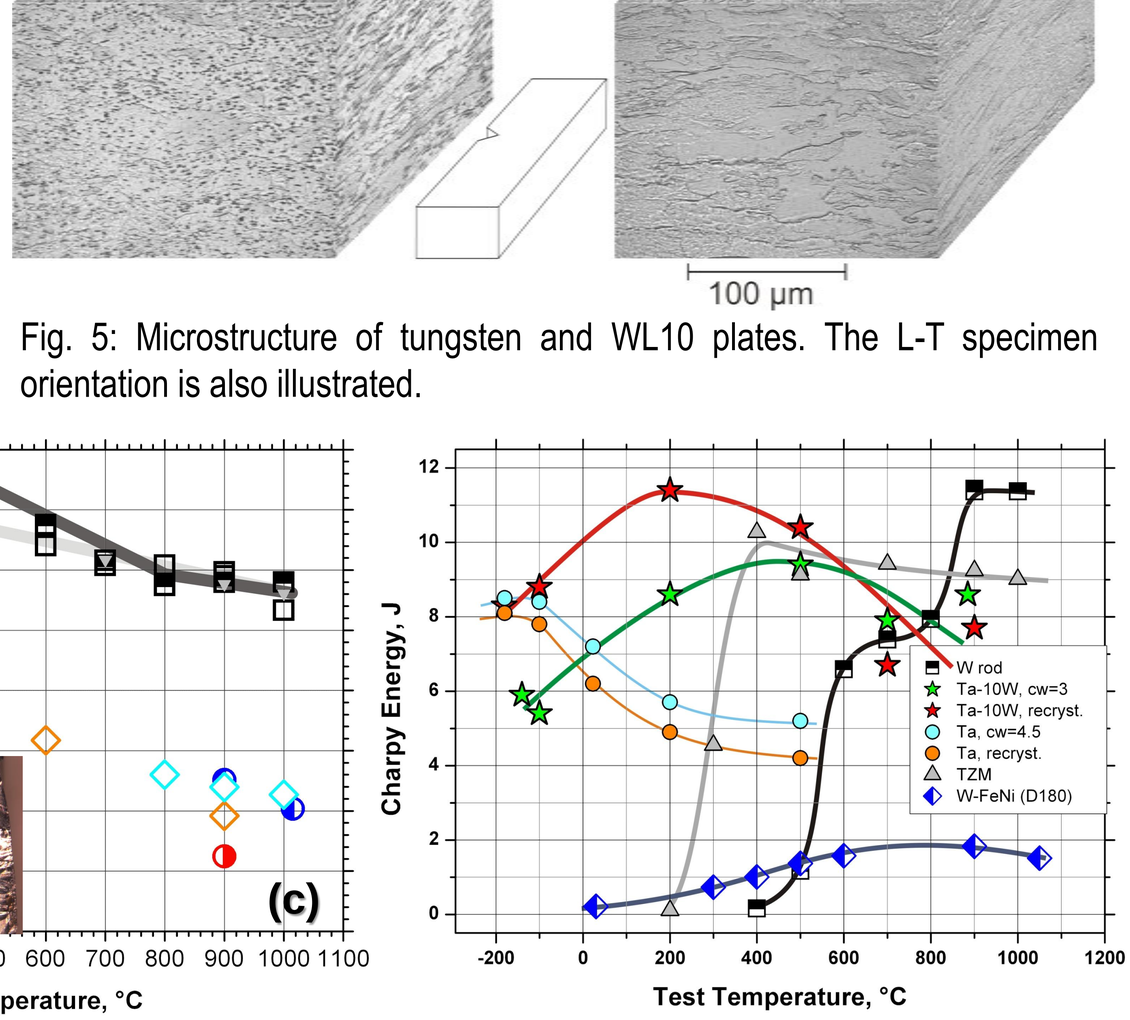
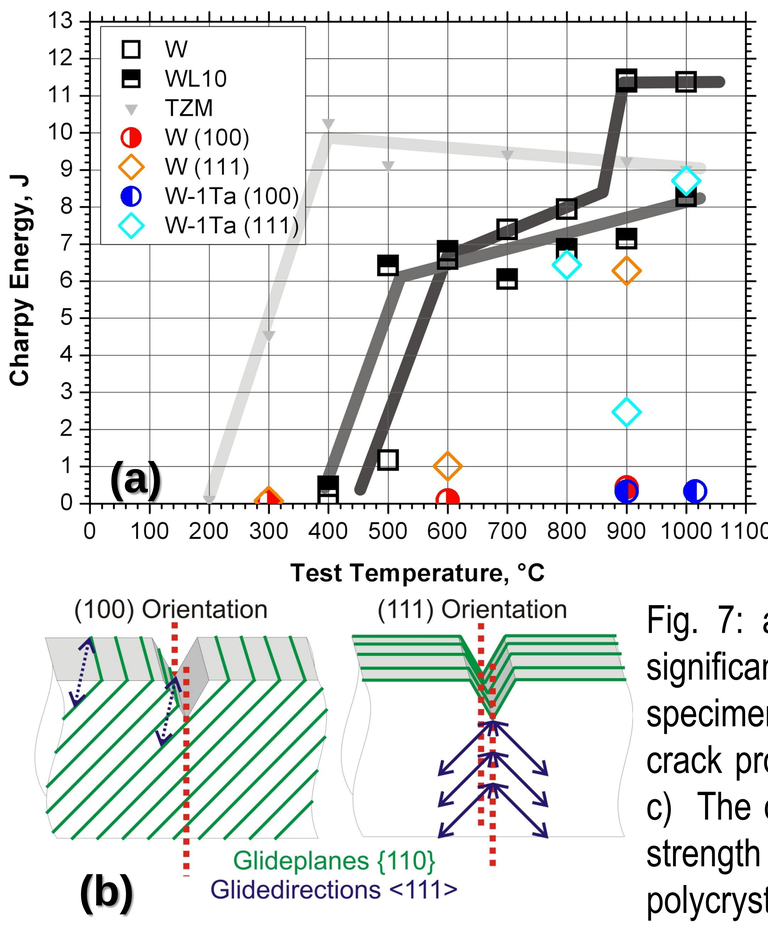


Fig. 5: Microstructure of tungsten and WL10 plates. The L-T specimen orientation is also illustrated.



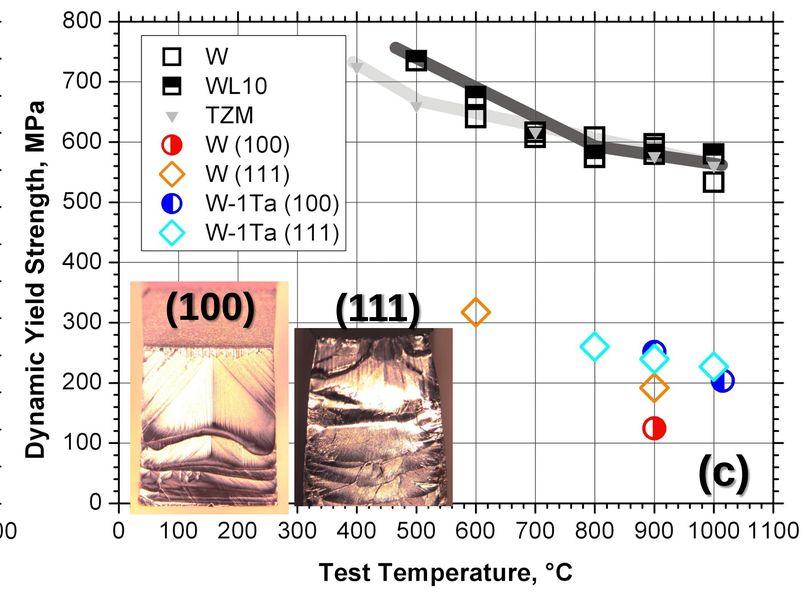


Fig. 7: a) The Single crystals with (111) orientation show a significant higher toughness compared to the (100) oriented specimens. The reason is the glide system which enables easier crack propagation in the case of (100) oriented specimens (b). c) The crack surfaces mirror the glide systems. Dynamic yield strength of all single crystals is clearly lower compared to the polycrystalline tungsten materials.

Fig. 8: A comparison with alternative materials shows that only Ta-W alloys might be candidates for structural applications: they are rather tough even well below room temperature and show a comparable strength to Mo and W at least up to 900 °C. Pure Ta is too soft while the composite (W-FeNi, or Densimet) is too weak.

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