# 9–10 Modification of Plasma-Facing Material

## — Modification of Vacuum Plasma Sprayed Tungsten Coating by Friction Stir Processing —

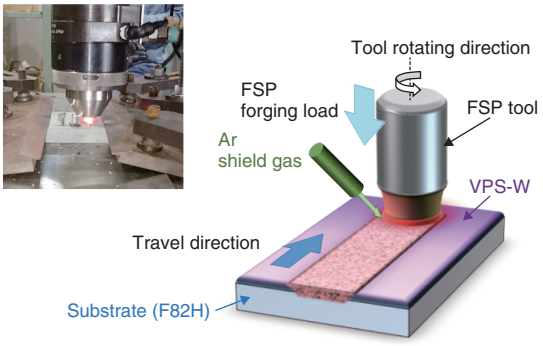


**Fig.9-25 General view of friction stir processing**
Friction stir processing (FSP) is a modification technology that can eliminate defects and increase the hardness of a material surface by friction heat and plastic flow induced by tool rotation and travel.

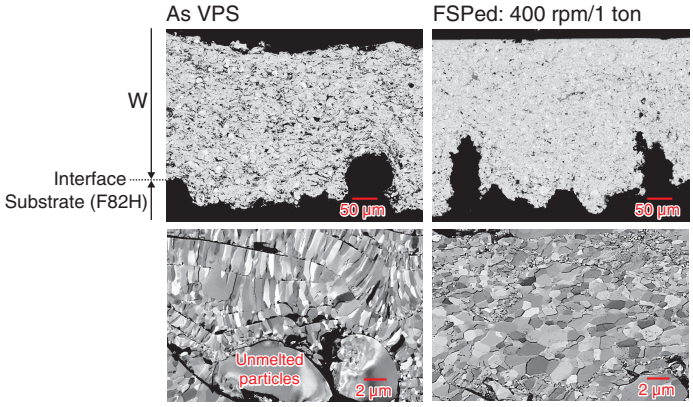


**Fig.9-26 SEM observation on VPS-W before and after FSP**
The elongated grains in as-VPS-W become finer and more uniform, and the number of interfacial cracks become much less after FSP is applied.

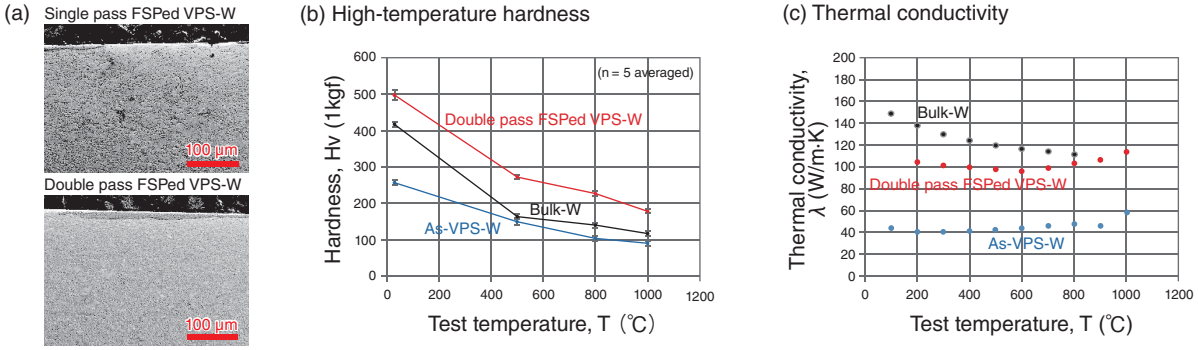


**Fig.9-27 Cross-sectional SEM images, temperature dependences of high-temperature hardness, and thermal conductivities of double-pass FSPed VPS-W, as-VPS-W, and bulk-W**
Grains become more equiaxed and uniform in the double-pass FSPed VPS-W (a); the FSPed VPS-W is harder than bulk-W and VPS-W in all temperature ranges (b); and the thermal conductivity of the FSPed VPS-W is 80% of that of bulk-W at 200 °C and becomes equivalent to that of bulk-W at 800 °C (c).

Tungsten (W) is the primary candidate for a plasma-facing material in fusion devices, due to its high melting temperature, good thermal conductivity, and low sputtering rate.

The vacuum plasma spray (VPS) technique has been investigated, as it is practical for coating a large area. The issues are that the thermal conductivity of VPS-W is significantly lower and the hardness of VPS-W is much less than those of bulk-W.

Friction stir processing (FSP) is a modification technology that was successfully demonstrated on thermally sprayed cemented carbide layers, which are used as the base materials for cutting tools, dyes, and molds. FSP was applied to VPS-W in this study to solve the issues related to VPS-W (Fig.9-25). The elongated grains in as-VPS-W were found to become finer, equiaxed, and uniform when the VPS-W was FSPed, and the number of interfacial cracks and pores became much less in FSPed VPS-W (Fig.9-26). The remaining gaps between stirred grains in the single-pass FSPed VPS-W were almost gone in double-passed FSPed VPS-W, and grains became more equiaxed and uniform (Fig.9-27(a)). High-temperature hardness tests revealed that the FSPed VPS-W was harder than bulk-W and VPS-W in all temperature ranges and that the thermal conductivity of the FSPed VPS-W is 80% of that of bulk-W at 200 °C and became equivalent at 800 °C (Figs.9-27(b) and (c)).

This study was conducted as collaborative research with Professor Hidetoshi Fujii of the Joining and Welding Research Institute, Osaka University.

**Reference**

Tanigawa, H. et al., Modification of Vacuum Plasma Sprayed Tungsten Coating on Reduced Activation Ferritic/Martensitic Steels by Friction Stir Processing, Fusion Engineering and Design, vols.98–99, 2015, p.2080–2084.