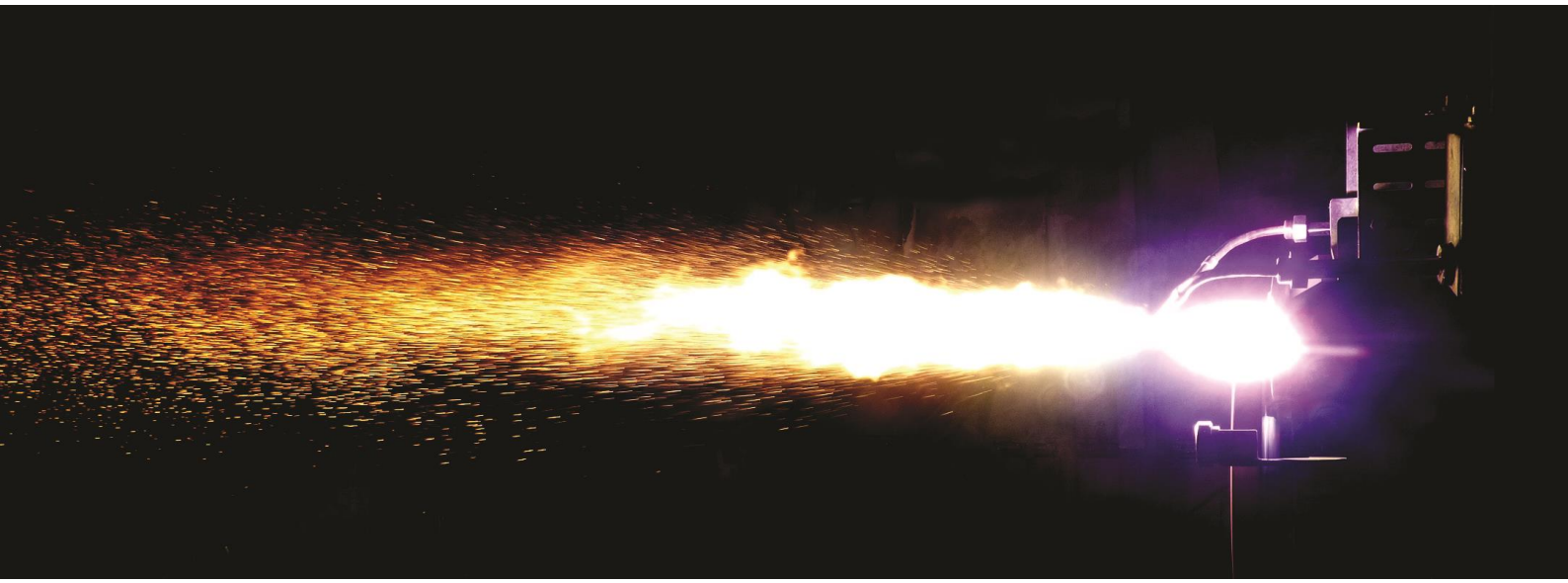
www.wsp-h.com



Hybrid Water-Stabilized Plasma Torch WSP®-H 500

Highest powder/liquid throughput plasma torch on the market

Innovative engineering: **Hybrid WSP**

The novel Hybrid Water-Stabilized Plasma torch combines the advantages of traditional DC gas-stabilized arc torches with the uniquely designed water channel which supplies the plasma arc with hydrogen and oxygen. With a consumption as low as 15 slm of argon and 20 ml/min of demineralized water, the WSP-H system can continuously operate at power level of up to 180 kW.

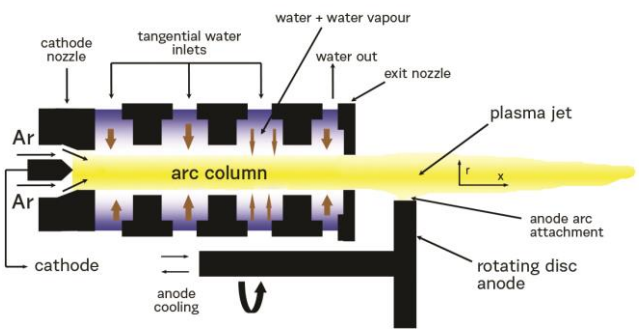
IPP

ProjectSoft®

v2

Reliable Plasma Generation Concept

Based on the original Water-Stabilized Plasma (WSP) torch concept which has been serving in the industry for heavy-duty plasma spraying for more than 30 years, the Hybrid WSP (WSP-H) torch brings major improvements to the reliable day-to-day operation. The Hybrid WSP technology introduces Ar gas and W cathode into the rear part of the water channel which ensures easy „click and spray“ operation of the torch, higher reliability and longer continuous operation, while the high plasma energy is maintained.



Schematic cross-section of the plasma jet generation.

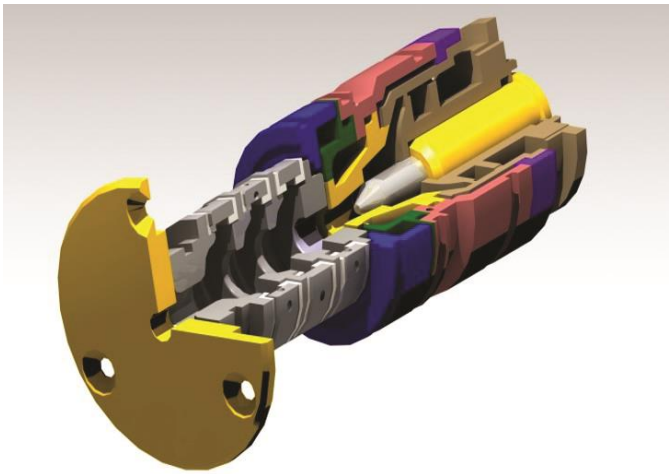
Hybrid WSP Torch Specifications*

Operation power: 100 — 180 kW
Arc current: 350 — 600 A
Argon flow: 12 — 35 slm
Water consumption: ~ 1 liter/h
Feed rates:

- ceramic powders: up to 700 g/min
- metallic powders: up to 500 g/min
- suspensions/solutions: up to 200 ml/min

Plasma temperature at the exit nozzle: ~ 25 000 K
Plasma velocity at the exit nozzle: up to 7000 m/s
Plasma enthalpy: ~ 300 MJ/kg

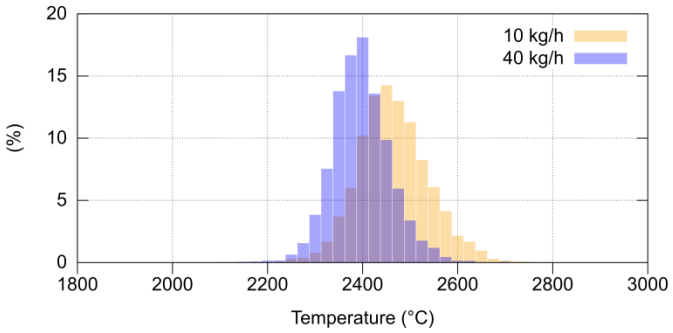
* *typical values depending on torch configuration*



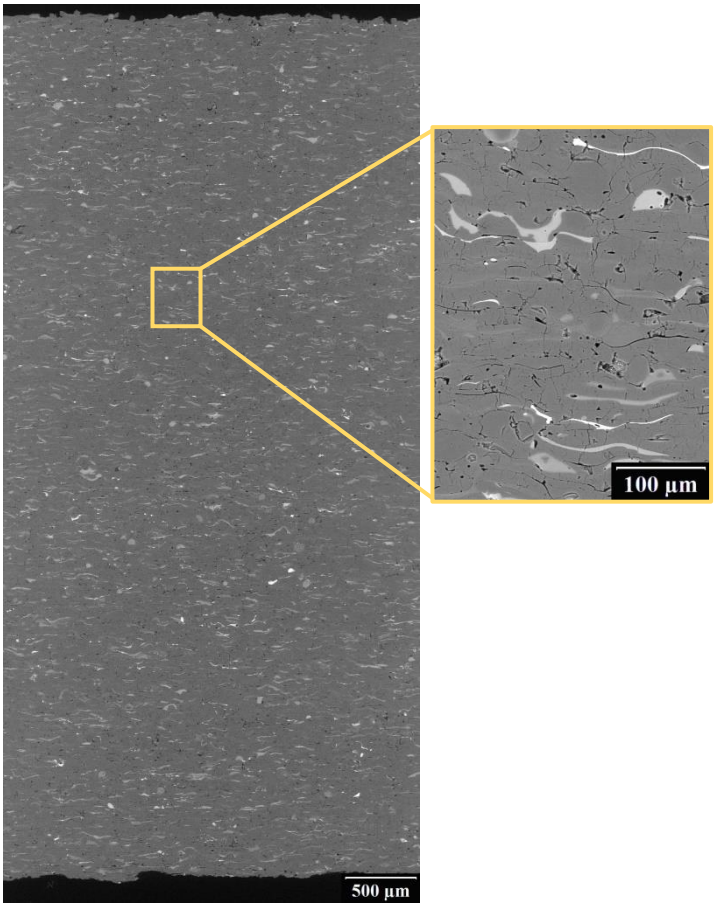
Plasma generator assembly.

High Temperature & Enthalpy System

The Hybrid WSP plasma torch operates at adjustable power from 100 up to 180 kW. Compared to the other high energy plasma torches, the Hybrid WSP has one order of magnitude higher plasma enthalpy. The high power and high plasma temperature of the WSP-H torch make it ideal for cost-effective high throughput spraying of high melting temperature ceramic (e.g. Cr_2O_3, YSZ) and metallic (e.g. W, stainless steel) powders as well as suspensions and solutions.



The plot illustrates that even at high throughputs there is just negligible change in particle temperatures as measured by the DPV 2000 diagnostics for Al_2O_3 powder. Al_2O_3 particles are heated well above the melting point of Al_2O_3 (2050 °C) even at 40 kg/h powder feed rate.

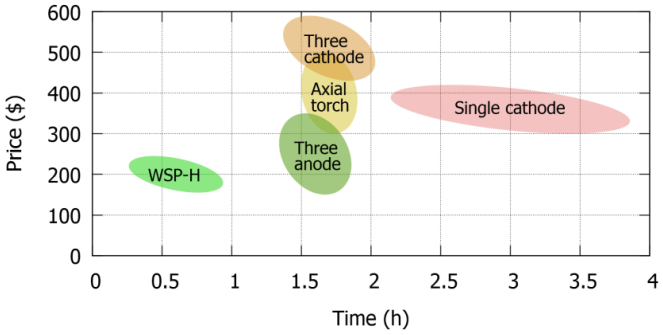


Cracks-free homogeneous microstructure of 6 mm thick free-standing coating (brown alumina).

Hybrid WSP Saves Your Money

The unique WSP-H is the most economic plasma spraying system available. Given the combination of low running costs (typically consuming just 15 slm of Argon and 20 ml/min of demineralized water) and superior material throughputs (up to 40 kg/h), its economy is unmatched by gas-stabilized plasma torches. This ultimate solution saves your money and spray time, as demonstrated in a case study below.

Case study: Spraying of Al_2O_3



Rough comparison to other atmospheric plasma spraying systems (APS), when 10 kg of Al_2O_3 is deposited onto a part. The calculation takes into account the operational costs, torch deposition efficiency and consumed powder. 1 kg Al_2O_3 = $15.

Typical feed rates and deposition efficiencies

Material [Feedstock type]	Feed rate (g/min) (ml/min)	Deposition efficiency (%)	Application example
Al_2O_3 [powder]	700	70-85	Free standing parts
YSZ [powder]	350	50-56	TBCs
$ZrSiO_4$ [powder]	400	65-73	EBCs
Al_2O_3 [suspension]	120	55-60	Wear resistant coatings
YSZ [suspension]	100 - 200	50-55	TBCs

Versatile and Precise Feeding

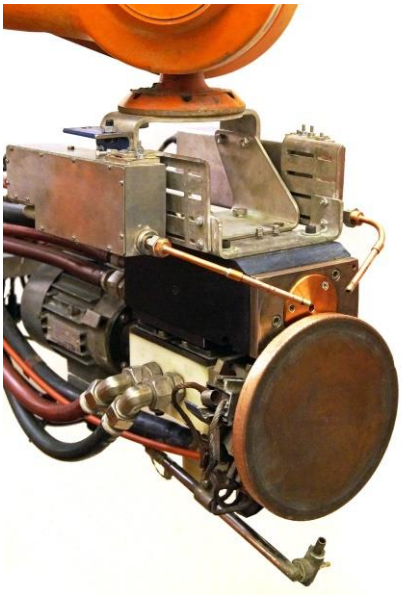
Different feedstock materials (powders as well as liquids) can be injected simultaneously through up to three injection lines to deposit single phase, composite, or even graded coatings.

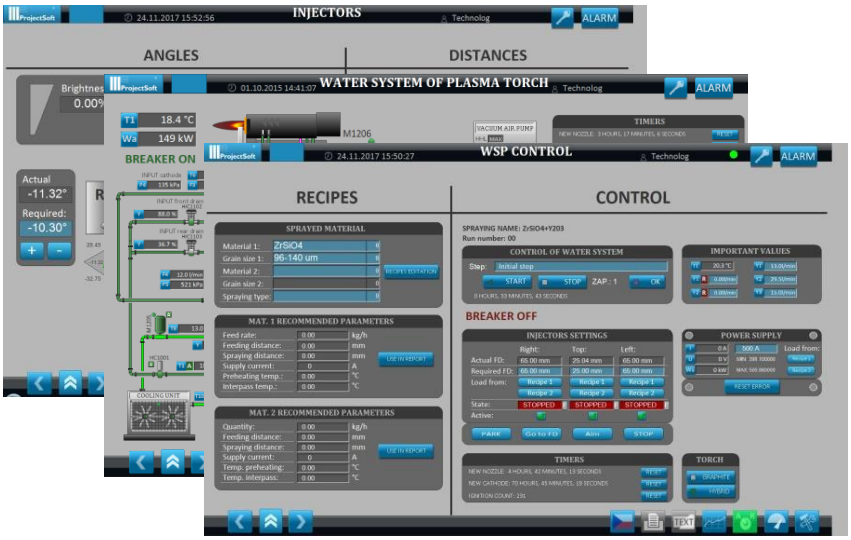
To ensure the highest spray efficiency, the materials are introduced into the plasma jet using self-adjusted multi-injection feeding system. The automated routine always finds the optimum feedstock injection “sweetspot” for each of the three injectors.

Complete System Delivery

The WSP-H torch is a complete industrial-design spray system. It comes fully equipped with DC power supply, water system with process feedback control, and water coolers.

The operation of the system is controlled by modern software tailored for day-to-day easy use and equipped with spraying parameter library.





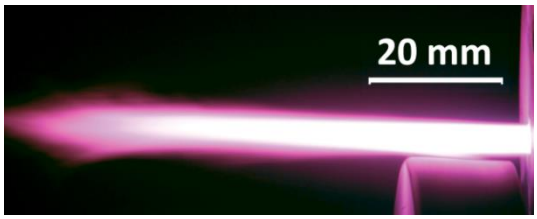
Graphical user interface for WSP-H control.

Spraying Routes

WSP-H technology works with various types of feedstocks allowing spraying of:

- coarse dry powders
  - *traditional spraying route*
  - *high deposition rate → thick coatings*
- liquids (suspensions & solutions)
  - *controllable ultrafine microstructures*
  - *novel functional properties*
- co-spraying of powders and liquids
  - *so called "hybrid spraying"*

Different spraying routes and versatility of WSP-H technology allow optimization of coatings micro-structure and functional properties for various applications.

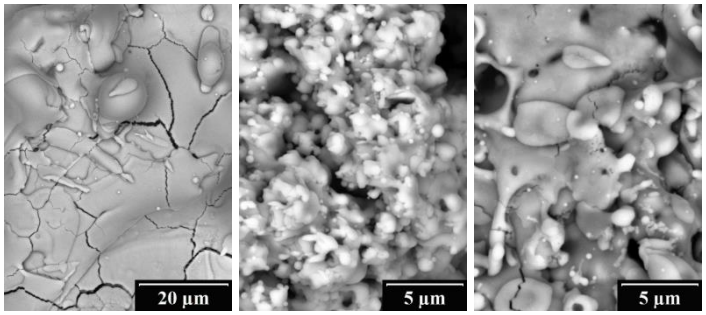


Long WSP-H plasma jet.

Typical spray parameters

Route	Dry powders	Liquids
Mean feedstock size	50 - 150 µm	0.05 - 5 µm* only liquid#
Injection distance	30 to 80 mm	20 to 30 mm
Stand-off distance	250 to 500 mm	100 mm
Feed rate	200 to 600 g/min	100 to 150 ml/min

*Note: *suspension, #solution.*



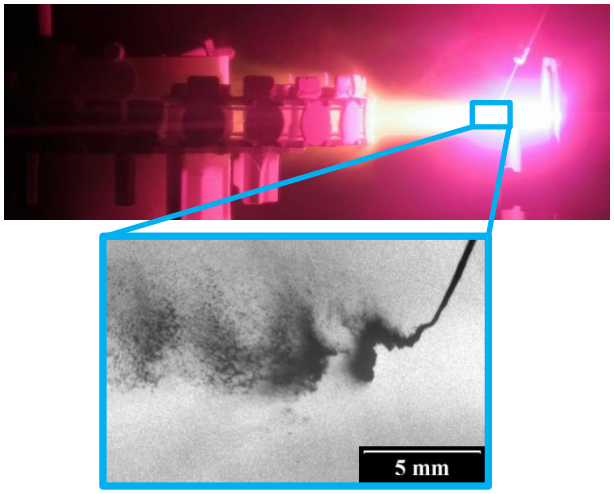
powder *suspension* *solution*

YSZ splats on coating free surface.

Suspension/Solution Plasma Spraying

Long WSP-H plasma jet and its high energy enable proper fragmentation and thermal treatment of large amounts of liquid feedstocks, allowing efficient evaporation of liquid carrier and resulting in rapid coating build-up.

WSP-H plasma torch was proven to be capable of spraying more than 200 ml of liquid per minute.



Liquid fragmentation in the long WSP-H plasma jet.

Samples with deposited Al_2O_3.

Liquid Feeding System

WSP-H system may be equipped with dedicated 2nd generation liquid feeder, which was designed to inject suspensions and solutions with high feed rates (up to 300 ml/min).

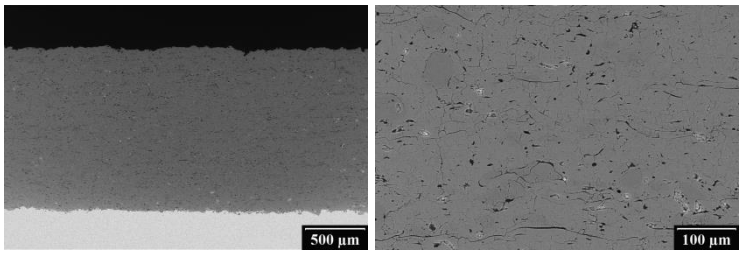
Selected features:

- On-line flow rate control (Coriolis flow meter).
- Pneumatic operation (pressure up to 8 bars).
- 3 x 5 liters containers for continuous deposition.
- Stirrer and peristaltic recirculation preventing suspension sedimentation and clogging.
- Touchscreen control from your mobile or PC.

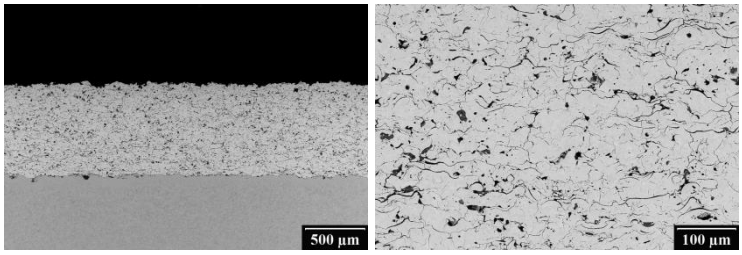
WSP-H Versatility

Spraying Powders

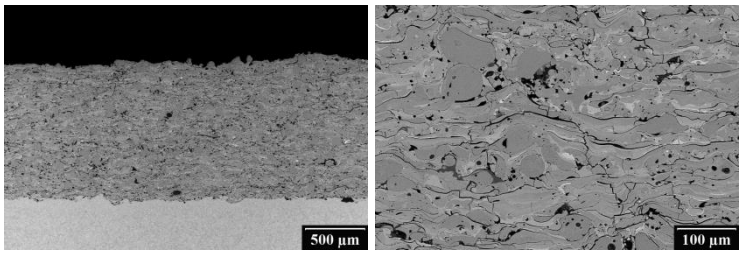
Ceramic Coatings



Al_2O_3

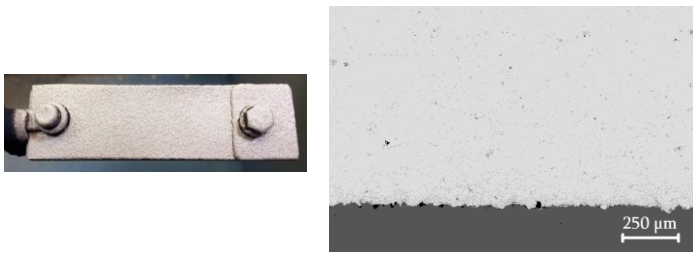


Yttria-stabilized zirconia (YSZ)

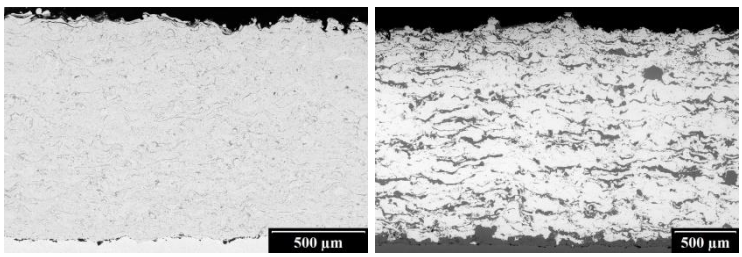


$ZrSiO_4$

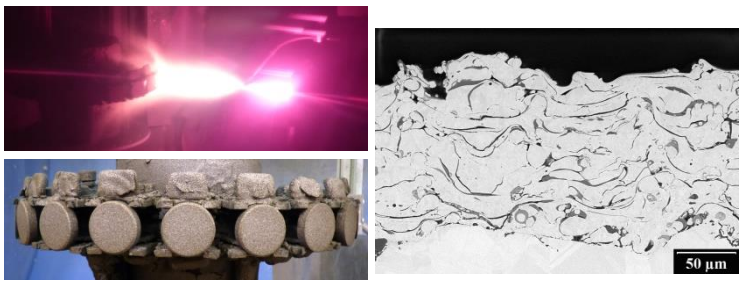
Metallic Coatings



Tungsten deposited on steel (shrouded deposition)

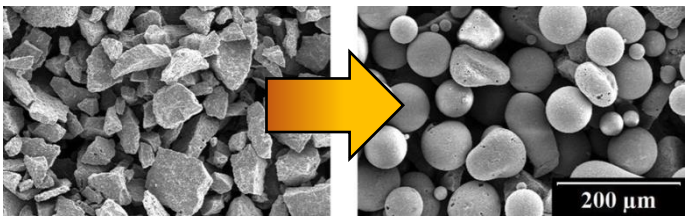


AISI 410 and AISI 410+W coatings (shrouded deposition)



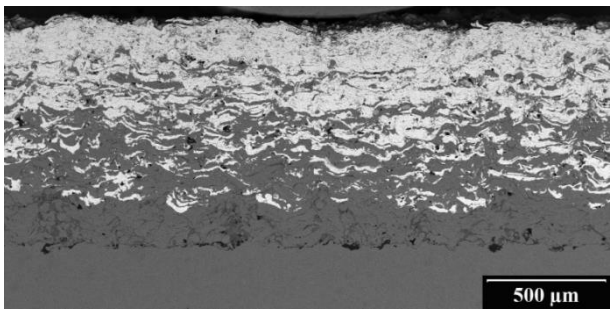
NiCrAlY (open air deposition)

Spheroidization – 40 kg/h of Powder



Spheroidization of Al_2O_3 powder

Functional Metallic Coatings



Functionally graded tungsten-stainless steel coating

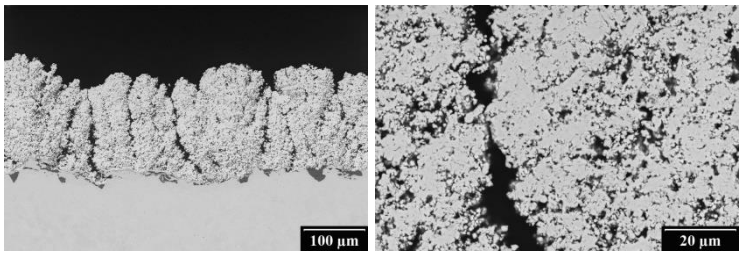
Free Standing Coatings

Examples of Industrial Applications

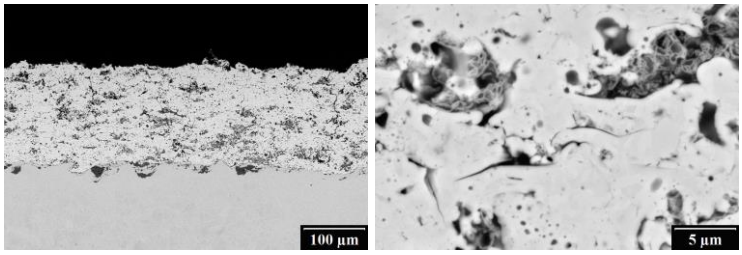
WSP-H Versatility

Spraying Liquids

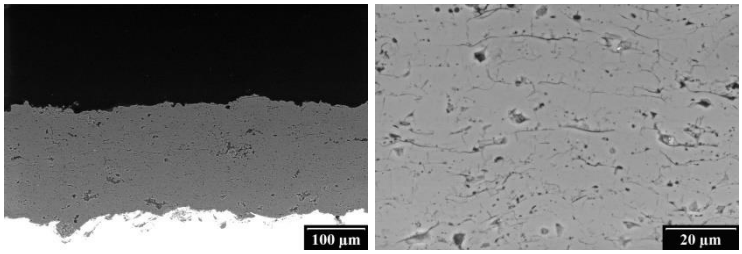
Coatings Deposited from Liquids



Columnar strain-tolerant YSZ (K~0.6 W/m.K) from suspension

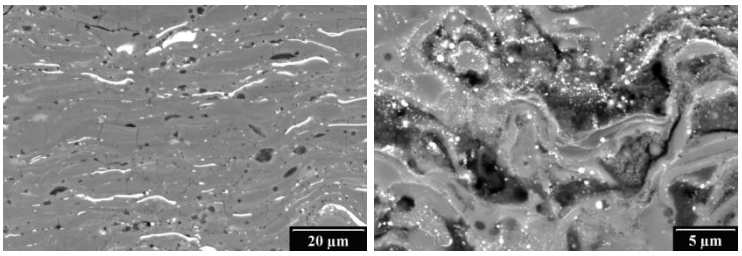


Semidense YSZ (K~0.6 W/m.K) from solution

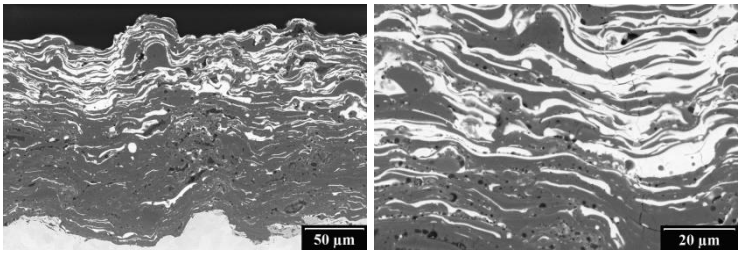


Hard dense Al_2O_3 (HV ~1200) from suspension

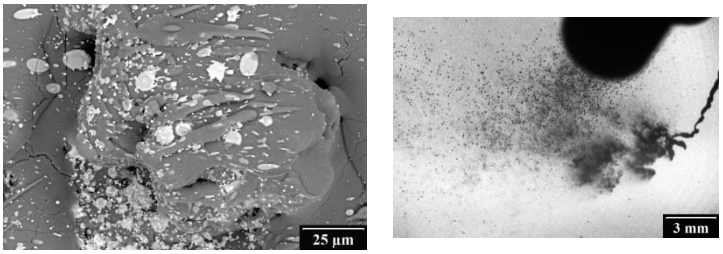
Ultrafine Composite Coatings



YAG in Al_2O_3 *nano-Ag in hydroxyapatite*

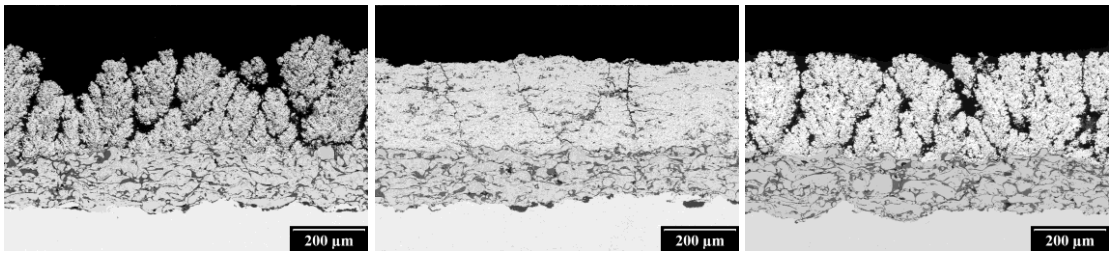


Gradient Al_2O_3 → YAG coating



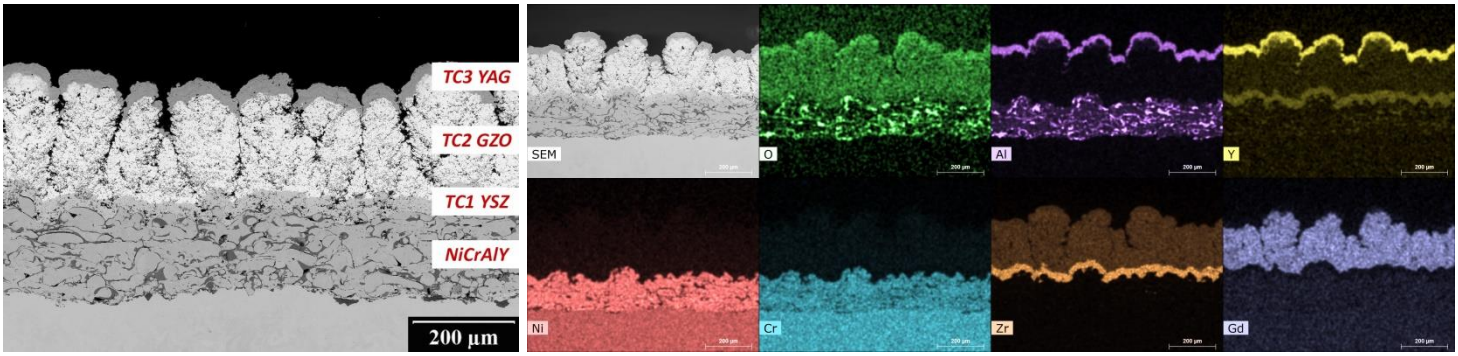
Co-spraying fine YSZ suspension and coarse Al_2O_3 powder

Layered Thermal Barrier Coatings (TBCs) on NiCrAlY Bondcoat



YSZ from suspension *YSZ from solution* *$Gd_2Zr_2O_7$ from suspension*

TBCs deposited from liquids performed in thermal cycling fatigue (TCF) tests better than conventional TBCs deposited from powder.



Multilayered TBC - NiCrAlY (powder), TC1 YSZ (solution), TC2 $Gd_2Zr_2O_7$ (suspension), TC3 YAG (suspension)

more info: www.wsp-h.com

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