Tribological performance of nanostructured TiO2 coatings prepared by Suspension HVOF spraying

F. Zhang[1], S.C. Wang[1], B. Robinson[2], A. Tabecki[3], H.L. de Villiers-Lovelock[3], R.J.K. Wood[1]

1. National Centre for Advanced Tribology (nCATS), Faculty of Engineering and the Environment, University of Southampton, Southampton, SO17 1BJ, UK
2. University College London, Dept of Chemistry, London, WC1H 0AJ, UK
3. TWI Ltd, Granta Park, Great Abington, Cambridge, CB21 6AL, UK

Introduction

Suspension spraying, as a modification of conventional thermal spraying, has attracted increasing levels of attention in the last few decades. The employment of a liquid phase in the suspension instead of dry powders provides good flowability of nano-sized or sub-micron sized feedstock and makes it possible to maintain the nanostructure of the feedstock and obtain very thin coatings (tens of micrometres). It has been demonstrated that nanostructured coatings has enhanced hardness and deformation resistance [1]. However, their tribological performance has not been fully studied yet. Researches are still needed to reach a better understanding.

High velocity oxy fuel (HVOF) spraying was chosen to be used in our study, which has been widely applied for depositing cermet and oxide ceramic coatings with excellent wear resistance [2]. The study focuses on the influence of various parameters on the coating structure and comparing the difference of their tribological behaviour. It is expected that the reseach will contribute to the theoretical knowledge as well as the applications of thermal spraying technology.

Methodology

Suspension HVOF Spray Parameters

- TopGun torch
- Propylene flow rate: 80.5 Slpm, Oxy flow rate: 280 Slpm
  Or Hydrogen flow rate: 788 Slpm, Oxy flow rate: 264 Slpm
- Number of passes: 15
- Suspension injection nozzle:0.3 mm/conical
- Suspension feed rate: 20 ml/min
- Suspension: 5 wt. % nano-TiO_2 (diameter 25 nm) + 95 wt.% Liquid (Mixture of H_2O and Isopropanol)

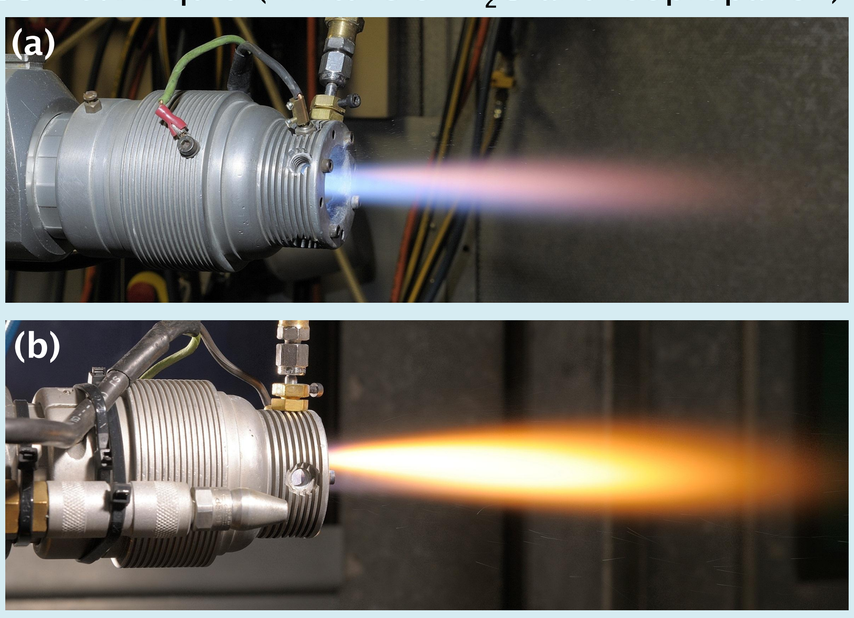

Fig. 1 (a) Propylene flame and (b) Hydrogen flame during suspension HVOF process (Taken by TWI).

Table 1 HVOF spray parameters of three coatings

Coating	Fuel	Spray distance	Suspension liquid phase
P-130	Propylene	130 mm	100 % H_2O
H-100	Hydrogen	100 mm	100 % H_2O
H-150	Hydrogen	150 mm	90 % H_2O

Wear Test

All the wear tests were carried out under 5N by reciprocating TE77 high frequency friction machine at room temperature under dry sliding conditions for 600s. 6 mm Al_2O_3 ball was as the counter-body.

Results

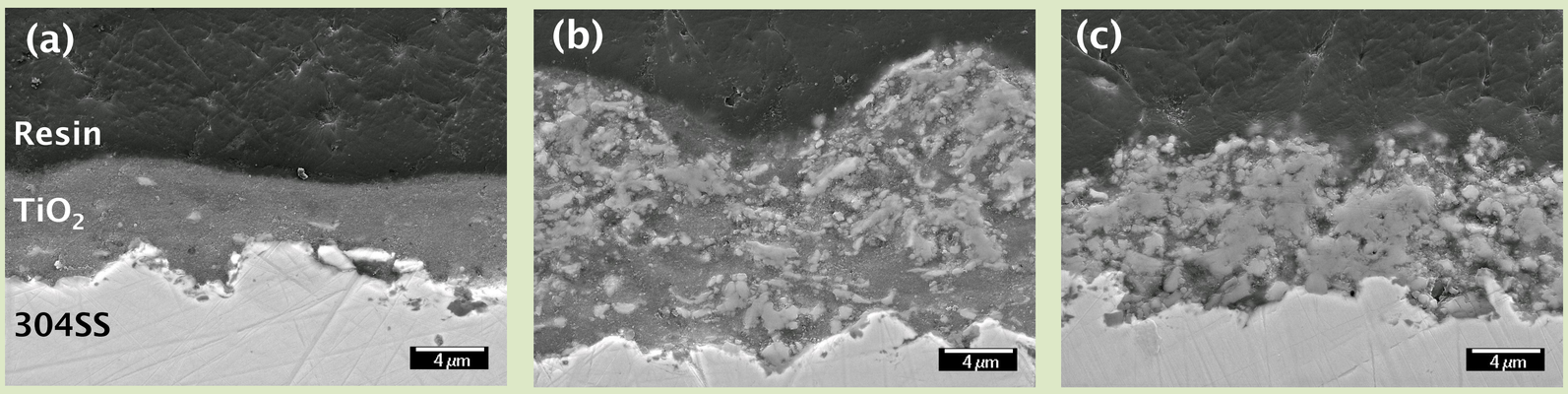

Fig.2 SEM images of coating microstructure. P-130 (a), H-100 (b) and H-150 (c)

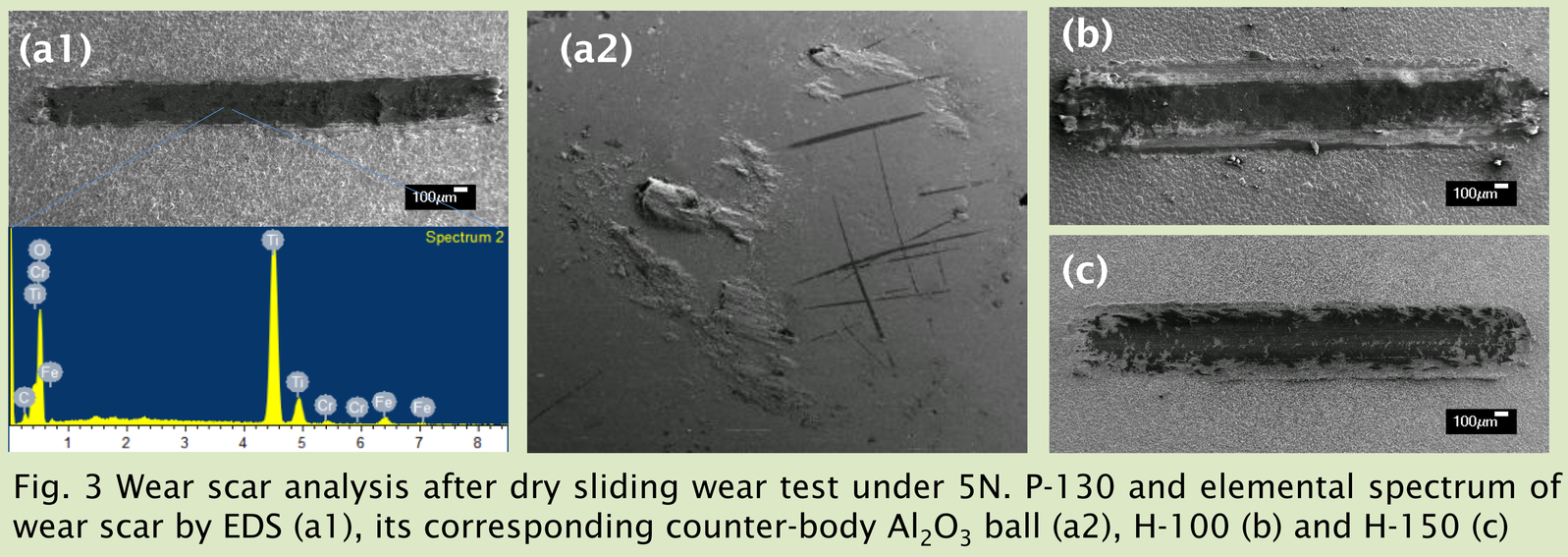

Fig. 3 Wear scar analysis after dry sliding wear test under 5N. P-130 and elemental spectrum of wear scar by EDS (a1), its corresponding counter-body Al_2O_3 ball (a2), H-100 (b) and H-150 (c)

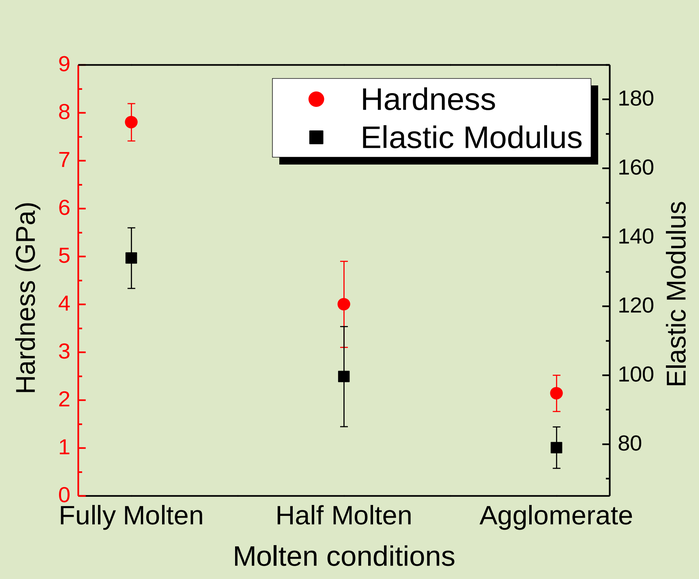

Fig. 4 Values of Hardness and Elastic modulus under different molten conditions of Suspension HVOF sprayed TiO_2 coating by nanoindentation

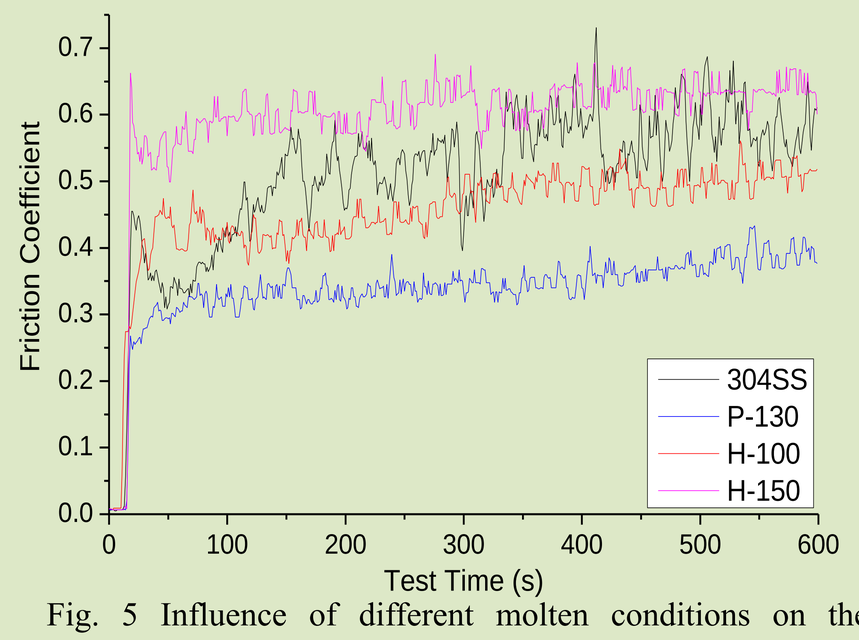

Fig. 5 Influence of different molten conditions on the tribological behaviour of suspension HVOF sprayed TiO_2 coatings.

Conclusions

In conclusion, very thin coatings (< 10 μm) were successfully deposited by TiO_2 nanoparticles by means of suspension HVOF spray technology. Different coating structure can be achieved by adjusting the spray distance, the fuel and the proportion of H_2O and isopropanol in the suspension. The increase of agglomerate TiO_2 particles can highly decrease the coating hardness and elastic modulus. However, the presence of agglomerate nanoparticles enables the decrease of friction coefficient under dry sliding conditions by increasing the conformability of the coating and thus promoting the formation of tribo-film on the contact surface under certain load.

References

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[2]Nieminen, R., Vuoristo, P., Niemi, K., Mäntylä, T. and Barbezat, G., Wear 212 (2006). pp. 66/77.

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www.soton.ac.uk/nCATS | email: F.Zhang@soton.ac.uk
National Centre for Advanced Tribology (nCATS), Faculty of Engineering and the Environment, University of Southampton, SO17 1BJ, UK.