Porous flame sprayed Al_2O_3 coating for slippery liquid infused surface

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Thermal spraying is a cost-effective and practical surface engineering method to produce coatings with different thicknesses on several substrates by using a variety of different feedstock materials [1]. Thermal spraying combines kinetic and thermal energies to form the coating from feedstock material onto the substrate. The feedstock materials, e.g., ceramics, metals, polymers or composites are melted during the coating processing, and therefore, technically any material, which can be melted are good candidates for thermal spraying. Thanks to flexibility in the choice of feedstock materials and substrates, thermal spraying is being used in a wide range of applications, e.g., in corrosion protection, biomedical applications, anti-icing, and many more [2].

Flame spraying is one of the most common thermal spraying methods. The heat is generated by combustion of fuel gas, usually acetylene, and oxygen to melt the feedstock material and then, a molten material is accelerated and propelled onto the substrate, where it solidifies and form the coating. Depending on the process parameters selected, dense coatings can be produced as well as for the specific purposes, relatively porous structures can be obtained by flame spraying [2]. One interesting approach to manufacture, e.g., slippery and icephobic coatings, is to produce porous coatings by flame spraying for SLIPS (Slippery Liquid Infused Porous Surfaces) [3]. The main methodology behind SLIPS is trapping an immiscible lubricant, like oil, inside the porous structure to repel various types of substances, like water. It has been studied that SLIPSs can be used in different applications like corrosion protection, hydrophobic surfaces, and anti-icing surfaces, depending on the lubricant type and coating characteristics [4]. This work aims to produce porous ceramic coatings by flame spraying and evaluate suitability of their microstructures for SLIPS. Alumina (Al_2O_3) was selected as a feedstock material, and it was used as a form of flexi-cord wire, where faceted Al_2O_3 powders (Fig. 1a) were surrounded by a polymeric binder.

Flame sprayed alumina (FS Al_2O_3) coating was highly porous (Fig. 1b), which was the target in this study. The Al_2O_3 particles were molten and accelerated towards the surface of the grit-blasted stainless-steel substrate, forming a relatively thick ceramic coating. Typically flame sprayed coatings include pores, oxide inclusions and some other defects caused by the nature of the coating process [1]. The overall view of the polished cross-section of the coating (thickness ~380 µm, Fig. 1b) was taken using a backscattered electrons detector (BED) in a scanning electron microscope (SEM). It is possible to see internal porosities in the structure as well as open porosities to the surface. Higher magnification of the coating microstructure (Fig. 1c) highlights the random distribution of pores between the lamellar structure of the coating. Evidently, micron-sized pores and some cracks are formed at the splat boundaries of solidified molten particles, having a connection path through the coating towards the top surface. SEM micrograph (Fig. 1d) shows an open porosity to the surface structure which is appeared as the result of the molten particles impact and solidification. The morphology of feedstock material is changed to rounded splats in the flame spray process; however, build-up of splats can produce a relatively rough surface. Ideally, the lubricant can infiltrate inside the coating and fill the internal porosities toward the provided diffusion path, and form lubricant micro-reservoirs inside the coating.

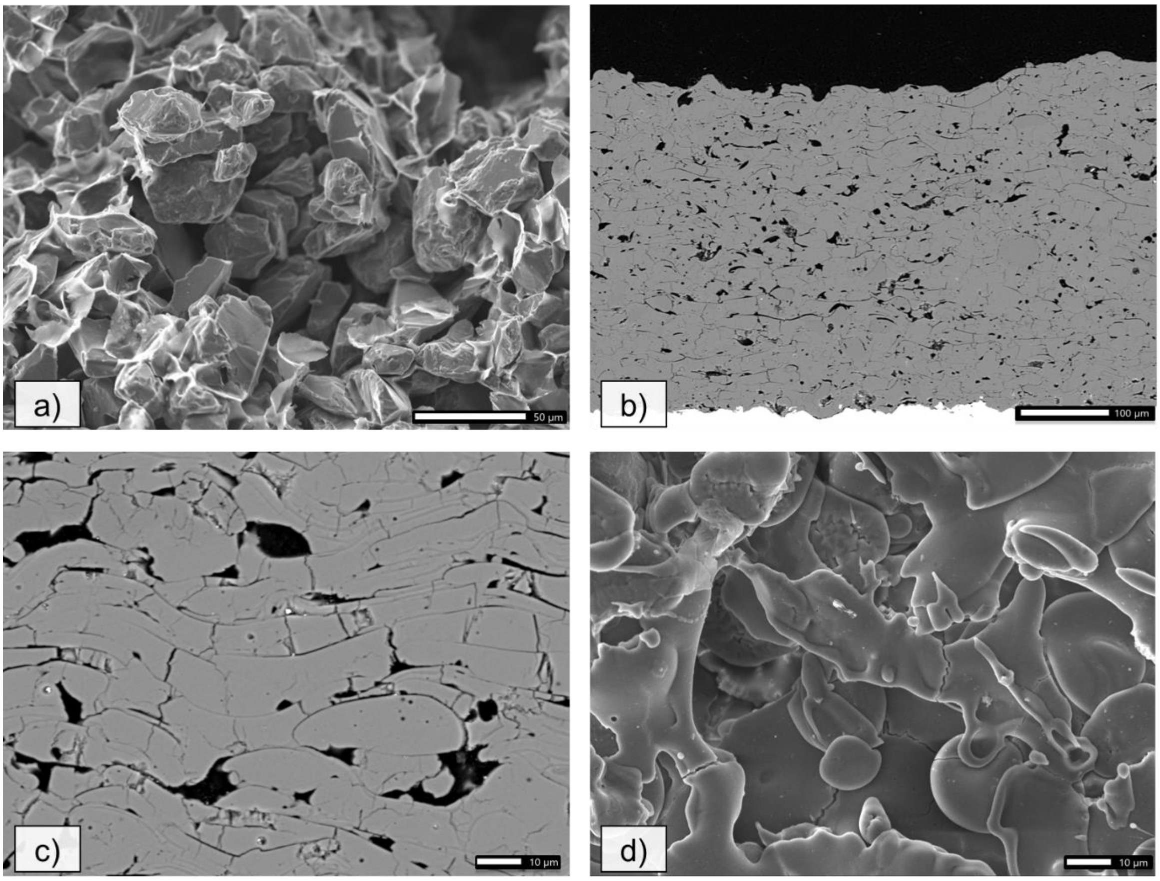

Figure 1 SEM images of a) morphology of flexi-cord feedstock, b) FS Al_2O_3 coating on grit-blasted stainless-steel substrate, c) microstructure of porous FS Al_2O_3 coating and d) surface structure of FS Al_2O_3 coating.

Flame spraying is the surface engineering method to produce relatively thick and porous coatings. FS Al_2O_3 coating was characterized by SEM to investigate the porous structure for the optimization of lubricating coating. In the scope of this research, porosity is an important feature, which is desired to further design of slippery surfaces, SLIPS, towards anti-icing applications.

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