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Study of the local segregation of multi-component powders during a plasma spray process for biological applications

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Atmospheric plasma spraying is a versatile coating process, which can be utilized for biomedical applications. The use of powder mixtures consisting of different materials allows the fine-tuning of specific coating properties. For instance, by addition of a small amount of Cu to TiO_2 powder, antimicrobial coatings on implant surfaces can be generated. However, the achieved functionality depends heavily on the particular coating structure.
Our investigations show that the different components in the powder mixture can segregate during the plasma spray process on the way from the injection to the substrate. The segregation can be ascribed to different particle sizes (a few tens microns in diameter) and relevant material properties (e.g. density and melting) of the constituents. The segregation causes gradients in the chemical composition of the coating. Coating depositions with a mixture of TiO_2 and 3% Cu revealed a lateral deviation of the resulting elemental profiles of up to 2 cm as verified by XPS analysis. Depth profiles were prepared and analyzed by SEM. Actively utilizing the effect of material segregation, different coatings (maximum of Cu at the top and close to the substrate) could be produced demonstrating that the deposition of coatings with controlled material gradients is feasible. This opens prospects for films with tailored local properties for biomedical applications. According to our analysis, the gradient coatings display different dynamics of copper release over time.
The results show the components in powder mixtures employed for plasma spraying need to be selected carefully. Particle sizes and the material properties have to be considered for spatially homogeneous coatings. However, the segregation can also be used for the deposition of coatings with controlled material gradients.

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