

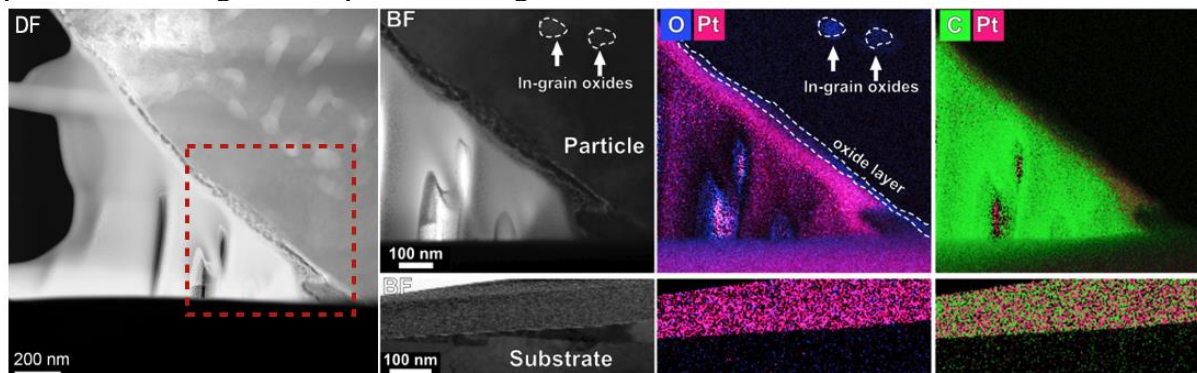
## The Influence of Interfacial Chemistry on Bonding During High-velocity Impact of Microparticles

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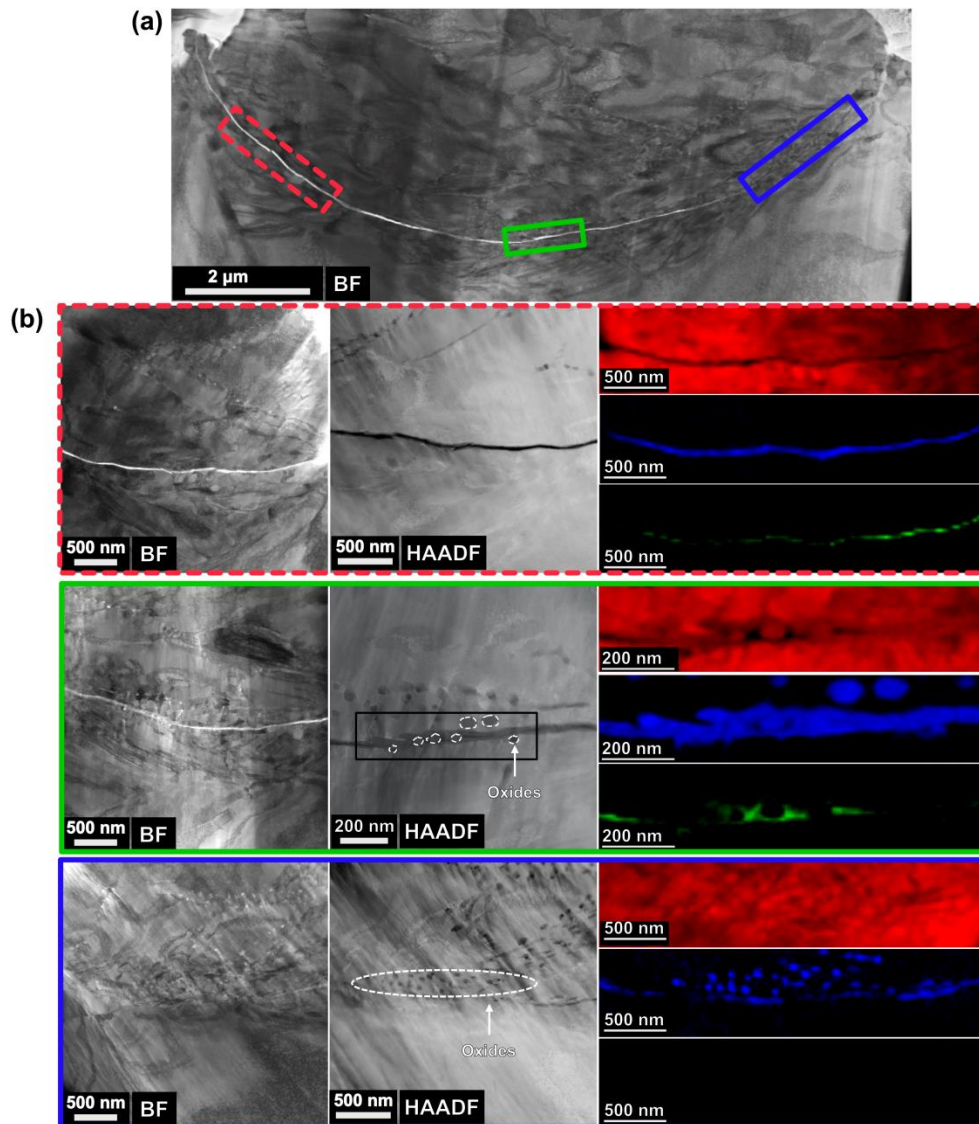
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Cold gas dynamic spraying, often referred to as cold spraying (CS), has become an essential process to produce surface coatings. During this process, powder particles are deposited in the solid-state at high velocities onto a substrate to form a coating. CS uses kinetic rather than thermal energy for deposition so that undesired oxidation and chemical reactions are avoided to enable complex material designs with intermixing of different materials or to repair surfaces [1]. Successful permanent particle adhesion occurs above a critical velocity [2], where various phenomena can occur, including extremely localized deformation accompanied by adiabatic heating [3], development of mechanical interlocking at the interface [4], and the interaction of strong pressure waves with the expanding edge of the deforming particle [5]. For most metals, there is a broad understanding that the most effective CS bonding requires a breakdown of the native oxide layers on the surface of the particle and substrate to permit metal-on-metal contact and bond formation [6]. However, detailed studies of the chemistry of these oxides and their role on metallurgical bonding is scarce, and we therefore aim to provide a *site-specific* comprehensive analysis of oxide chemistry across the particle-surface interface of permanently-adhered particles.

In this presentation, observations from a model Cu system to investigate a unit process of CS will be discussed. We conducted site-specific analyses of surface oxide chemistry for individual particle impacts, from particles of well-known sizes previously launched with a laser-induced particle impact tester (LIPIT) [7,8]. To prepare these samples for electron microscopy, lamella at the center of particle-substrate bonded sites for different impact velocities were extracted using a FEI Helios 660 Nanolab Dual-Beam FIB/SEM system. Combining STEM imaging and spectroscopy with high spatial resolution, we analyze the chemical components at the particle-substrate interface. As shown in Figure 1, the unimpacted particle is characterized by the presence of a surface oxide whose thickness varies from 10 – 50 nm, while near-absence of surface oxide is found on the mirror-polished substrate. Furthermore, the starting particle contains ~65 nm-sized spherical oxide particles that are buried in the particle itself, some of which are close to the particle surface. Using imaging and spectroscopy, we will discuss the role of both native surface and intraparticle oxides on particle-substrate interfacial bonding during impact, as shown in Figure 2. We will also discuss the existence of amorphous carbon at the interface, from the particle periphery to the south pole, and by extension, its possible role in bonding. Aided by the high spatial resolution and chemical analysis of STEM, we will highlight how nanoscale investigations of a unit process of CS provide new insights to improve bonding.



**Figure 1.** STEM chemical maps and images of the sample before impact. The surface of the particle and the substrate before impact is mapped with EDS with O given in blue, Pt in purple, and C in green.



**Figure 2.** EELS analysis of the interface on different sides of sample 647 m/s. (a) Bright field STEM across impact interface and (b) BF and HAADF images, and EELS maps of the corresponding regions marked in (a) with Cu signal given in red, O in blue and C in green. Intraparticle oxides are marked in the HAADF images.

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