MECHANICAL BEHAVIORS OF AGGLOMERATED CERAMIC POWDERS FOR COLD SPRAYING APPLICATIONS

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Cold spray (CS) is a low temperature and high velocity powder deposition process that is increasingly used in industry for coating solutions or for the repairing and the manufacturing of components [1]. This process is particularly well suited to ductile metals and provides dense materials with minimal oxidation or phase transformation effects [3]. For brittle materials, such solid-state deposition process is still questionable and presents new interesting challenges [3]. Recently, some works on $Ti0_2$ or hydroxyapatite powders has shown that ceramic powders can be deposited by CS [4,5,6,7]. However, the nature and the architecture of the powder may influence drastically the impact features of single particles. In addition, there is a need for advanced characterization of the deformation behavior of individual ceramic particles, especially in case of agglomerated nanostructured powders. In this work, the deformation of agglomerated ceramic powders involving ultra-fine grains under high velocity impact by CS is studied. Two different powders, respectively 3YSZ and Y_2O_3, were investigated and their morphologies observed by SEM after various impact conditions. In parallel, micro-mechanical experiments were performed on individual powder particles. In situ SEM nano-indentation and FIB–milled micro-pillar compression tests were developed at low displacement speed, 0.01µm/s (Fig1). The resulting data and observations allowed to analyze the deformation and damaging behaviors (swelling, compaction and shearing). According to these results, a Drucker-Prager law was fitted successfully in FEM to establish mechanical properties of the powder under compression. Such micro-mechanical methodology could be applied for higher deformation rate and help to discriminate ceramic agglomerated powders also investigated by cold spray.

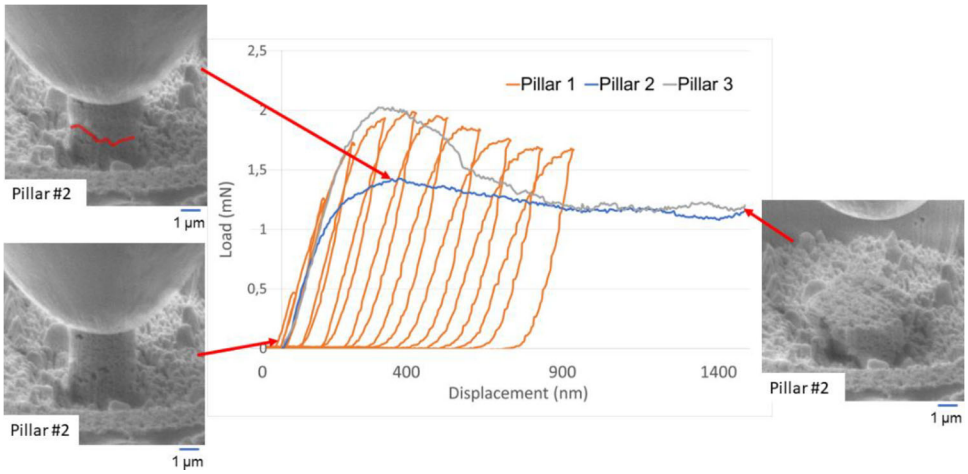

Figure 1: Load-displacement curves of micro-pillars compression tests

[1] A. Papyrin, Cold spray technology, 1. ed. Amsterdam: Elsevier, 2007
[2] W. Li et al., Solid-state additive manufacturing and repairing by cold spraying: A review, J. of Materials Science, 2018.
[3] CERASOL project (ANR-19-CE08-0009)
[4] E. Kergourlay et al., First Cold Spraying of Carbonated Biomimetic Nanocrystalline, Advanced Engineering Materials, 2016
[5] D. Moreau et al., Cold Spray Coating of Submicronic Ceramic Particles on Poly(vinyl alcohol) in Dry and Hydrogel States, Journal of Thermal Spray Technology, 2017
[6] G.-J. Yang et al., Low temperature deposition and characterization of TiO2 photocatalytic film through cold spray, Applied Surface Science, 2008
[7] L. Kong et al., Fabrication Of Y2O3 Coatings By Cold-Spray, AML, 2019