**Proceedings of the Canadian Society for Mechanical Engineering International Congress 2022**
**CSME Congress 2022**
**June 5-8, 2022, Edmonton, AB, Canada**

# Fracture and Fragmentation Modelling of Ceramics for Cold Spray Additive Manufacturing

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## Abstract

This study explored physics-based modeling of dynamic fracture and fragmentation of boron carbide towards developing a robust model describing the impact deposition processes of metal matrix ceramic-reinforced composite coatings (e.g., Al-$B_4C$). The model used a Johnson-Holmquist-Beissel (JHB) constitutive law to describe the high strain-rate behavior of the boron carbide ceramic reinforcement phase, and a modified Gurson–Tvergaard–Needleman model to describe the behavior of the aluminum metal matrix. The JHB model was implemented in both Abaqus and LS-Dyna using a discrete finite element modeling framework to capture important fracture and fragmentation mechanisms that occur during cold spray deposition. The model was first validated experimentally with split-Hopkinson pressure bar tests (e.g., Brazilian disk, compression) using stress-strain and fragmentation measurements. While reasonable agreement was obtained between experiments and models, parameter study results reveal sensitivities between model inputs (e.g., peak strength) and key metric outputs (e.g., damage patterns, stress-time response). The model was refined by validating the damage patterns observed during impact experiments with those from previously published studies, where results reveal additional sensitivities of model inputs and outputs (e.g., fragmentation outcomes) under impact conditions. Once validated, the model was used to explore the role of reinforcement particle size and impact deposition on resulting matrix deformation and porosity in Al-$B_4C$ composite coatings. Overall, this research informs design and fabrication of next-generation composite coatings in future studies.