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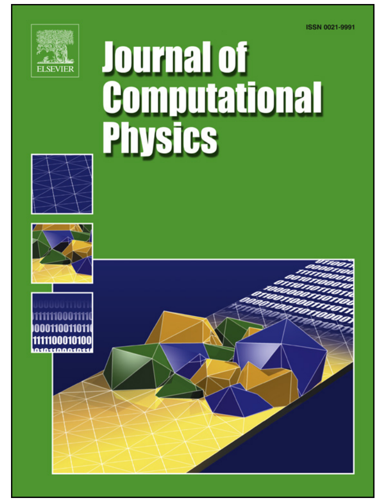

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Computational modeling of electrically-driven deposition of ionized polydisperse particulate powder mixtures in advanced manufacturing processes

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A key part of emerging advanced additive manufacturing methods is the deposition of specialized particulate mixtures of materials on substrates. For example, in many cases these materials are polydisperse powder mixtures whereby one set of particles is chosen with the objective to electrically, thermally or mechanically functionalize the overall mixture material and another set of finer-scale particles serves as an interstitial filler/binder. Often, achieving controllable, precise, deposition is difficult or impossible using mechanical means alone. It is for this reason that electromagnetically-driven methods are being pursued in industry, whereby the particles are ionized and an electromagnetic field is used to guide them into place. The goal of this work is to develop a model and simulation framework to investigate the behavior of a deposition as a function of an applied electric field. The approach develops a modular discrete-element type method for the simulation of the particle dynamics, which provides researchers with a framework to construct computational tools for this growing industry.

Keywords: powders, polydisperse, deposition, electromagnetics

1. Introduction

A large variety of emerging advanced fabrication methods involve Additive Manufacturing (AM) processes, which are generally characterized as depositing materials onto substrates and bonding them together to create structures, as opposed to classical "subtractive" processes which remove material. The approach was pioneered in 1984 by Hull [40] and was a 2.9 billion dollar industry in 2015, with applications ranging from motor vehicles, consumer products, medical devices, military hardware and the arts. We refer readers to a recent review of the state of the art by Huang et al. [38]. A subclass of AM processes involve "dry" powder deposition. "Dry" powder deposition approaches (where the interstitial space between particles is not saturated with a liquid) do not utilize solvents, since the deposited material will be heated or cured afterwards in order to harden it into place. Interstitial solvents are avoided because they can compromise the resulting hardened material quality, due to gas bubbles, mass-transport induced cracking, etc., during curing. *However, the precise deposition of dry powders is difficult.* It is for this reason, electrically-driven methods are being pursued, whereby the dry particles are ionized and an electric