Challenges and Opportunities for Machine Learning Approaches for Sintering and Microstructure Development

Rajendra Bordia and Fei Peng
Materials Science and Engineering, Clemson University, Clemson, SC 29634 USA

There have been significant developments in the use of machine learning for guiding the development of sintering protocols for ceramics. The current status of the field will be reviewed with a focus on the challenges and opportunities that this approach presents. One of the primary limitations is the lack of robust and large number of training data sets. One way to address this limitation is thru the use of high throughput experiments.

We will present results on one high throughput study. Ultra-fast laser sintering of alumina that achieves the desired density (e.g., 80 – 98 % relative density) and microstructure (e.g., grain size) for alumina within ~10 seconds was conducted. A sample array of ~80 sample units (~500 µm × 500 µm × 100 µm each) can be sintered simultaneously under one laser scan, which results in various microstructures for each sample unit due to the laser power distribution. The hardness of each sample unit and corresponding microstructure were characterized to efficiently establish the datasets for machine learning (ML) training. The hardness vs. relative density data obtained from this high throughput method, well match the literature data. We developed convolutional neural network (CNN)-based ML algorithms that can precisely predict the laser-sintered alumina microstructure from the hardness values and precisely predict the hardness of the laser-sintered alumina from the SEM micrographs with less than 5 % error. The grain size- density trajectory for laser sintered alumina was compared to furnace sintered samples and the similarities and differences discussed.