EPSTEIN INSTITUTE SEMINAR ▪ ISE 651

Ceramic Binder Jetting Additive Manufacturing: Three Methods to Increase Density

ABSTRACT - Binder jetting additive manufacturing has demonstrated significant potential in printing ceramic parts because it has little geometry limitation and is easy to scale up. Currently, the bulk density of ceramic parts by this process ranges 40–68%, far below the requirement for load-bearing applications. There are three causes for the low density: low packing density of the powder bed, limited sintering of the printed part, and low flowability of the feedstock powder. Three methods were investigated to improve the part density. To increase the powder bed density, ceramic powders with different particle sizes were mixed under the guidance of a particle packing model. Results show that mixed powders have higher powder bed packing densities and sintered densities than the corresponding constituent powders. To increase the powder sinterability, coarse crystalline alumina particles were coated with amorphous alumina, forming a core-shell structure. The coarse crystalline core can help maintain the high flowability and the amorphous shell can promote sintering due to its high activity. To increase the powder flowability, a powder granulation method was investigated by preparing microsized breakable granules from nanosized alumina powder. A bulk density of 80–90% was achieved on printed and sintered alumina parts, breaking the record in the literature. These three methods and consequently the improved density can help enable widespread applications of ceramic binder jetting additive manufacturing.

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SPEAKER BIO – ZJ Pei is a professor in the Department of Industrial and Systems Engineering at Texas A&M University (TAMU). He is the holder of Texas A&M Engineering Experiment Station (TEES) Research Professorship. He is also the Director of Research Development for TEES. Prior to joining TAMU in August 2016, he was a professor and the inaugural holder of Ice Professorship in the Department of Industrial and Manufacturing Systems Engineering at Kansas State University. From November 2016 to November 2017, he was an American Society of Mechanical Engineers (ASME) Foundation Swanson Fellow, serving as the Assistant Director for Research Partnerships at the Advanced Manufacturing National Program Office hosted by National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland. From August 2012 to August 2016, he served as the Program Director of the Manufacturing Machines and Equipment program at NSF, and received Director's Award for Excellence Program Director. He has served as an associate editor for four journals and an editorial board member for seven journals. He serves as the Technical Program Chair for the 2019 ASME Manufacturing Science and Engineering Conference; and Technical Program Co-chair for the 2018 ASME Manufacturing Science and Engineering Conference. He holds three patents, and has published more than 160 journal papers and more than 150 conference papers. He is a fellow of ASME and Society of Manufacturing Engineers (SME). He received his PhD degree in Mechanical Engineering from University of Illinois at Urbana-Champaign.

ZJ's research interests are in both additive and subtractive manufacturing processes. His past research activities were in the following three areas: (1) machining of semiconductor materials, including grinding, lapping, and polishing; (2) ultrasonic vibration assisted grinding of difficult-to-machine materials, such as advanced ceramic materials, titanium alloys, rocks, and composite materials; and (3) manufacturing of biomass-based biofuels. These activities were supported by DoE, NSF, and industry. His on-going research activities are in the following four areas: (1) additive manufacturing (AM) or 3D Printing (3DP) of ceramic joint implants, using binder jetting; (2) AM/3DP of polymer medical models, using material jetting and vat photopolymerization; (3) AM/3DP of biomaterials using material extrusion; and (4) AM/3DP of concrete structures using material extrusion. These activities are supported by AFOSR, DoE, NSF, and industry.

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