University at Buffalo
Center for Computational Research

Multiphysics Modeling of Liquid Metal Printing for Additive Manufacturing

VADER Systems, headquartered in Buffalo, NY, is a Western NY start-up company that is developing high-speed cost effective metal additive manufacturing technology.

Using an innovative technology called "Liquid Metal Jet Printing" (LMJP), highly complex three-dimensional objects can be created by printing droplets of molten metal in layers.

In order to provide consistent high quality fabrication, complex computer modeling is needed to enable the rational design of the printer. This is why Vader Systems collaborates with University at Buffalo.

Company: VADER Systems
Industry: Metal 3D Printing
Location: Buffalo, New York
Website: http://www.vadersystems.com/

THE CHALLENGE

The main challenge in this project is modeling the multiphysics and multiscale nature of the LMJP process . LMJP is based on magnetohydrodynamics. It involves the liquefaction of solid metal and the pulsed pressurization of the molten metal to cause droplet ejection, which is achieved using a transient electromagnetic field. In addition to droplet generation, modeling is used to understand the behavior of liquid droplets on the substrate as they cool and coalesce to form an extended 3D structure.

Dr. Edward P. Furlani (Prof. of Chemical and Biological Engineering and Electrical Engineering) and Ph.D. candidate Ioannis Karampelas have developed numerical models to address these challenges and provide relevant rational design decision guidelines.

NEXT-GENERATION SOLUTIONS

By collaborating with UB, VADER Systems has access to the expertise and state-of-the-art computational electromagnetic and fluid dynamic (CFD) modeling capabilities that are needed to simulate the LMJP process and enable rational design of the Vader Systems 3D printer. The results generated to date include simulations of magnetohydrodynamic-based

droplet ejection, aerodynamics and cooling of droplets in-flight to the substrate, droplet impact and coalescence to form crude 3D printed structures.

Access to UB's high performance computing (HPC) resources is supported by funding from the Division of Science Technology and Innovation (NYSTAR) of the Empire State Development Corporation (ESD) and the New York State Regional Economic Development Council.

ECONOMIC IMPACTS

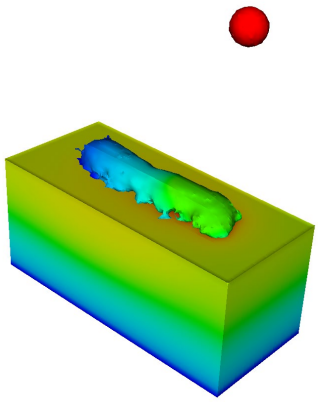
This work has supported the creation and commercialization of the Vader Systems' technology. In 2019 Xerox Corp. announced the acquisition of Vader Systems, moving its headquarters to the Xerox facilities in Webster, NY.

RESULTS

Due to the high computational demands of modeling an entirely new and innovative 3D printing system, only a high performance computing environment such as the one provided by UB's computational cluster can provide relevant results in reasonable time. For instance, a computational model of building a crude 3D structure through dropwise solidification requires taking into account the ejected droplet shape and size, droplet in-flight cooling, droplet impact, solidification on a substrate as well as the partial melting of solidified material by subsequently ejected molten metal.

Running such a highly complex multiphysics model even on high performance workstations can be prohibitive in terms of time. In addition, the data generated could even reach hundreds of Gigabytes. Therefore, successfully deconvoluting problems of such size and complexity requires the computational capacity of UB's Center for Computational Research.

The data generated is analyzed using UB CCR's remote visualization resources – a combination of high-end graphics hardware and client tunneling software. These services allow UB CCR to offer web-accessible remote desktop environments that run state-of-the-art visualization applications in a hardware accelerated mode. This results in an extremely responsive application that is free from jitter, latency, and buffering. In fact, application performance is often better than a conventional local installation. The graphic at right is from a recent analysis illustrating the initial stages of 3D printing a crude structure (wall) through dropwise solidification.



"The real world computing, engineering, physics, software and related expertise of Dr. Furlani and Ioannis Karampelas is a resource that was not practically available to us in any other way. We're making the decision to move our company onto the UB North campus to continue and expand our relationship with UB in large part due to the success of this initial collaboration." — Scott Vader, President and Cofounder, Vader Systems

ABOUT CCR

The Center for Computational Research (CCR), part of the University at Buffalo (UB), is a leading academic supercomputing facility. CCR maintains a high-performance computing environment, high-end visualization laboratories, and support staff with expertise in computing, visualization, and networking.

The mission of CCR is to (1) enable research and scholarship at UB by providing faculty with access to high-performance computing and visualization resources, (2) provide education, outreach, and training in Western New York, and (3) foster economic development and job creation in Western New York by providing local industry with access to advanced computing resources, including hardware, software and consulting services.

CONTACTS

Adrian Levesque, MBA
Center for Computational Research
University at Buffalo

701 Ellicott St., Buffalo, NY 14203
Office: (716) 881-8932
apl3@buffalo.edu

VADER Systems
Scott Vader

Phone: (716) 697-4967
scott@vadersystems.com