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Processing Technique for Ceramic-based Energy Conversion and Storage Devices (2020-015)

A novel integrated additive technique that reduces the manufacturing cost of ceramic-based conversion devices.

Market Overview

Due to rising carbon emissions, extreme weather events and other environmental threats, the demand for alternative energy sources is greater than ever. Therefore, businesses and communities are asking for three things: more affordable electricity, more resilient power, and cleaner energy. Fuel cells, electrolysis cells, membrane reactors, and solid-state batteries are the perfect energy source to fulfill those needs, but due to the costly manufacturing process, they remain cost prohibitive. Clemson University inventors have created a novel manufacturing technique, with integrated additive manufacturing and laser processing to reduce the costs of ceramic-based conversion and storage devices. The global additive manufacturing market was valued at $7.97 billion in 2018 and is expected to grow at a CAGR of 14.4% to a value of $23.33 billion by 2026. This unique process would not only cause the cost of energy storage to go down but will also decrease energy distribution costs and consumption prices.

Technical Summary

The additive manufacturing based micro extrusion, modified micro extrusion by doctor blade smoothing, spray coating, and inkjet printing allow the manufacturing of thin layers with thickness from 5- 2000 μm. The versatile geometries of tubes, cylinders, rings, lobed-tube, cones, thin films, half cells, single cells, and multilayer stacks, etc. have been successfully printed. Combined with laser cutting, more precise complex shapes can also be fabricated. The laser processing can make the fully dense membrane, highly porous membrane from cost-effective raw materials of carbonates and oxides, etc. The proper sintering additives are the critical factor for achieving crack-free large-area parts by rapid laser reactive sintering. The laser cutting of the green layers was developed, which allows one to build up microchannel with a width of less than 50 μm. The laser process also allows the manufacturing of half-cell (porous electrode supported with dense electrolyte) and single cells (two porous electrodes with dense electrolyte in between).

Application

Sustainability, Additive Manufacturing, Laser Processing, Energy Devices, Rapid Ceramic Processing

Development Stage

Proof of Concept

Advantages

- Rapid, cost-effective, and has high volumetric performance
- Could manufacture devices with complicated geometries and internal complexities
- Could become a catalyst for broader sustainable energy adoption

App Type	Country	Serial No.	Patent No.	CURF Ref. No.	Inventors
Patent	United States	62/955,780	N/A	2020-015	Jianhua Tong Hai Xiao Fei Peng Kyle Brinkman

About the Inventors

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Dr. Jianhua Tong is the principal investigator of the Sustainable Clean Energy Laboratory. Dr. Tong received his Ph.D. in 2002 from the Dalian Institute of Chemical Physics, Chinese Academy of Science. Before coming to Clemson in 2016, he had been working in the sustainable clean energy field for many years. His research interests focus on sustainable clean energy based on Solid State Ionic Materials and Devices including design and manufacturing of energy materials and devices. He is leading several additive manufacturing related projects supported by DOE-EERE, DOE-FE, NASA-EPSCoR, and Army VIPR-GS, etc. He held more than 13 patents and published more than 100 peer-reviewed papers.

Dr. Hai Xiao

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Dr. Hai Xiao is the Samuel Lewis Bell Distinguished Professor in Electrical and Computer Engineering. Dr. Xiao received his Ph.D. from Virginia Polytechnic Institute and State University in 2002. Prior to coming to Clemson, he was an associate professor of electrical engineering at Missouri S&T. He is the recipient of the Office of Naval Research Young Investigator Program Award, R&D 100 Award, and the Virginia Tech Outstanding Achievement Award. His research interests focus on photonic and microwave sensors and instrumentation.

Dr. Fei Peng

Associate Professor of Materials Science and Engineering at Clemson University

Dr. Fei Peng is an affiliated faculty member of the Clemson University School of Health Research. Dr. Peng received his Ph.D. from the Georgia Institute of Technology in 2009. His research focuses on the material fabrication and properties for medical and health applications, extreme environments and renewable energy. Dr. Peng has published 31 peer-reviewed journal papers and is the leading author of several highly cited papers in his field.

Dr. Kyle Brinkman
Professor of Materials Science and Engineering at Clemson University

Dr. Kyle Brinkman is a professor and chair in the department of Materials Science and Engineering. Dr. Brinkman received his Ph.D. from the Swiss Federal Institute of Technology in 2004. He was a part of the Clemson Department of Energy and the Savannah River National Laboratory where he was a principal engineer. Dr. Brinkman is the recipient of the SRNL Laboratory Director's Early Career Exceptional Achievement Award and the TMS Young Leader Professional Development Award. His research areas include ceramics, fuel cells, energy materials, interfacial engineering and crystalline materials for nuclear waste immobilization.

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