SNM: High-Throughput Electrospinning of Photocatalytic Mats for Energy Harvesting

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Objectives

The scope of our project is to advance ceramic nanofiber electrospinning ensuring high process yield, process and product repeatability and reproducibility, along with optimized quality control, resulting in a commercially viable, scalable, nanomanufacturing process that can produce functional nanoceramics.

- **Continuous Manufacturing of 3D, Heterogeneous, Nanostructured Grid-like Mats**
- **Mat dimensions**: 50cm wide, unlimited length-consisting of 20nm size particles
- **Mat will act as Visible-Light Photocatalytic Membrane for Solar Water Splitting**
- **Mat will Utilize the Whole Solar Spectrum and will Float on Water Ponds**

Continuous Production resulted in this large-scale nanostructured non-woven mat (unpublished Research, P. Gouma, SUNY SB)
Technical Barriers

3D ceramics are currently produced in lab-settings in minute quantities (0.2 kg/hr). The proposed methods are expected to increase their production rates up to several kg/hr so as to prove their nanomanufacturing both scalable and affordable.

- Use of a single step process to fabricate large scale nanofibrous ceramic mats

- Increasing the production rate while keeping the cost reasonable

- Fabricate self-supported 3D mats of ceramic nanofibers with controlled architectures for use in functional applications
Approaches for Meeting Challenges

- Novel High-Throughput Set-up Design
- Stabilizing the electric field at the tip
- Developing a rotating source system
- Mechanical characterization & modeling of the nanofibrous mats
- Assessing the quality of the photocatalytic mats based on Water Oxidation Catalysts
Novel High-Throughput Set-up Design

High-throughput Electrospinning Set-up developed by the research group of the PI (P. Gouma) at SUNY SB
**Novel Characterization Techniques**

**Spectrally-resolved transient emission spectroscopy**

- Time-resolved studies are necessary to determine the carrier separation rate.
- The technique measures time resolved emission spectrum over a wide spectral range.
- Based on an optically-gated Kerr medium, the gate pulse from Ti:Sa defines a sub-ps time delay window for the emission photons to transmit through a pair of crossed polarizers.

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Gas analysis tool under development. Residual gas analyzer was recently installed to analyze gas molecules with m/q 1 – 200. This will allow our team to measure PEC activity while performing gas analysis.
Expected Research Outcomes

Process Upgrade and Optimization through Iteration of:

- Modeling of the mat structures to guide the process design
- Mechanical property evaluation for optimization of process parameters
- Assessment of photoelectric properties to inform material selection and precursor parameters
Commercialization Opportunities

Industry interests:

- High-Throughput Electrospinning Process
- Photocatalytic Self-supported NanoMats
- New Energy Source (Water Ponds as Inexpensive Water Splitting Reactors)

Our interest is to set up a start-up to commercialize:

- novel nanomanufacturing equipment/process
- 3D ceramic photocatalytic non-woven mats
- solar water splitting reactor configuration

that will be produced in this work
Benefits of the SNM program

• The SNM program is excellent as it allows for interdisciplinary research at the forefront of nanotechnology and its applications.

• It’s unique focus on the scalable production of nanostructures, devices, and systems ensures that lab-based breakthrough research advances to the level of commercial-ready technology.

• This program takes technological advances to the next level while supporting fundamental research on materials and methods, both experimental and computer-simulated.

• For our team, SNM provides a unique opportunity to explore novel nanomaterial platforms, assess diverse applications for these materials, while at the same time we are developing scalable processes and methods for industrial production and use.