Technical Assistance Request (public)

Katsu Technologies Inc. is the prime contractor for Katsujinken Foundation, whose Mission is the acceleration of a Hydrogen economy for the benefit of the Earth's environment and the mitigation of climate change. Katsu Technologies Inc. is located in Willingboro New Jersey. Technologies under development include fell cells, thermoelectric materials, and synthetic fuels from seawater along with many technology transfers from Federal Laboratories (NASA, NIST and the NRL).

The innovation is a system for photocatalysis from seawater and large-scale nanostructure solar cells/arrays for demonstration and fabrication. Efficiency of the photocatalysis is the greatest challenge. Defects within crystalline photocatalysts can act as recombination sites, ultimately lowering efficiency. Photocatalysts can suffer from catalyst decay and recombination under operating conditions. Catalyst decay can become a problem with certain photocatalyst. These materials are formed and can be directly managed during the solution-phase crystallization during the roll-to-roll printing process. The results will define the design standards for high performance prior to implementation of a full production manufacturing capability.

Katsu Technologies seeks technical assistance in the prototyping and manufacturing of a system for the conversion of solar energy to hydrogen by means of photocatalysis. Thin film photovoltaics (PVs) are very attractive for low cost solar energy conversion, all integral to the photocatalysis system under development. Thin film solar cells fabricated extremely light weight with excellent flexibility, pushing the limits of size, weight, and power (SWaP) metrics, enable a wide range of applications of interest in different scales for deep space, atmospheric/oceanic, aerospace, and community based photovoltaic power generation.

Katsu Technologies seeks a MDF (Manufacturing Demonstration Facility) Technology Collaboration with the Department of Energy's Oak Ridge National Laboratory (ORNL) initiated by a Cooperative Research and Development Agreement to develop a Prototype, demonstration and eventual licensing of Roll-to-roll manufacturing processing, pulse thermal processes and other advanced processing technologies to develop low-cost manufacturing of the photocatalysts technology, photovoltaics, energy storage systems.

The baseline manufacturing capability that needs to be established is Roll-to-roll processing for thin film electronics using pulse thermal processing and other advanced processing technologies coupled with non-vacuum low temperature deposition techniques.

ORNL's high-density plasma arc-based pulse thermal processing (PTP) technology for rapid thermal annealing of nanostructured thin-films is viewed as the critical capability in this solution. Nanostructured materials are rarely synthesized with appropriate phase and morphology. PTP addresses critical additional steps of as-synthesized nanostructured materials, such as annealing, phase transformation, or activation of dopants, dramatically reducing the processing costs of thin film materials, including those in the area of photovoltaics. The high-density plasma arc lamp PTP capability allows controlled manipulation of materials on the atomistic scale. The large-area (up to ~1,000 cm^2) PTP capability is able to apply controlled heat fluxes (up to 20,000 W/cm^2) to large material surfaces with heating and cooling rates on the order of 10^4 to 10^6°C/s within milliseconds.

Three-dimensional (3-D) nanostructures have demonstrated the potential to boost performance of photovoltaic cells based on improved photon capturing capability. The challenge to Katsu Technologies is that due to utilization of ultra-thin material with limited light absorption capability and typically low crystalline quality, poor performance of thin film solar cells has placed them in a disadvantageous position when competing with crystalline Si based solar cells. Cost-effective and scalable fabrication of regular 3-D nanostructures with excellent robustness and flexibility is a challenging task and technology goal.

Based on the Katsu Technologies Research efforts, the competition between light absorption and carrier collection in conventional types of planar thin film solar cells makes further performance gains a challenging and fundamental research topic. Research has revealed that nanostructured substrates/templates can benefit performance of thin film solar cells, by introducing advanced light management schemes, such as photonic and/or plasmonic light trapping, and unique device design to improve minority carrier collection efficiency. While a number of different types of nanostructures have proven effective, there is still a lack of fundamental understanding on how morphological and structural change will affect the trade-off between photon absorption and carrier collection in a thin film solar cell. This is one challenge to developing effective design methods for high efficiency solar cells/arrays.

The Katsu Technologies effort will apply high-performance computational artificial intelligence (AI) systems, machine learning techniques, and algorithms to support scalable fabrication of regular 3-D nanostructures and the entire large scale nanostructure substrates fabrication roll-to-roll manufacturing line process, pulse thermal processing and other advanced processing technologies with continuous process improvements and material discovery of photocatalysts, photovoltaics, and energy storage systems. AI Machine Learned algorithms will identify and develop materials that better matches the bandgap of for solar cells that are more efficient at air mass coefficient AM0 and improved performance at AM1.5 for terrestrial solar panels.

Establishing effective design methods for 3-D nanostructured photocatalysts and solar cells/arrays with the balanced electrical and optical performance are of paramount importance and in urgent need for American manufacturing. Regular arrays of 3-D nanostructures need to be fabricated on flexible foil with a roll-to-roll compatible process. The nanostructures require precisely controlled geometry and periodicity which allow systematic investigation on geometry dependent optical and electrical performance of the cells with experiments, modeling, and simulations.

A demonstration of the nanostructured photocatalysts and solar cell processes to fabricate efficient solar panels with 3-D nanostructures, will have an immediate impact on Hydrogen Production and the thin film photovoltaic industry. Defining a practical, cost-effective, and scalable scheme to fabricate desirable nanostructures on flexible substrates is needed to advance the Hydrogen economy.

The technical assistance request is for the American-Made Network to assist in development of a low-cost process to fabricate perfectly ordered arrays of 3-D nanostructures on flexible substrates. These 3-D nanostructures will be formed using a defect nanoengineering approach in conjunction with scalable substrate anodization, with controlled geometries, (i. e. pitch and height) for use in large scale solar cells and photocatalysis demonstration and fabrication.