

Leap Photovoltaics is looking for a range of technical assistance, including expertise from collaborators and new team members, and access to equipment.

Our most urgent need is for a fluidized bed CVD reactor that can flow pyrophoric gases, including trimethyl aluminum and silane or trichlorosilane. Ideally, this system would also be capable of in situ etching (e.g., with HCl and/or HF gas) to treat surfaces before beginning deposition. We would like a new team member or collaborator who has some expertise with modeling and developing fluidized bed CVD processes, especially silane-based ones. We have had preliminary discussions with Dr. Madhava Syamlal at NETL about collaborating on modeling work and Dr. Shemi Elhadj at LLNL about collaborating on process development.

We are interested in developing wet chemical processing for powders. Access to equipment that can circulate powders in chemical baths, avoiding agglomeration and providing uniform reactions (etching, etc.) on powder surfaces would be helpful. Any expertise in applying wet chemistry to powders and controlling uniformity and etch rate would also accelerate process development.

We will use ray-tracing software to simulate the absorption of solar radiation in our PV device including the texture, thickness, and optical properties of the absorber, metallization, and thin-film layers in the device stack. For our devices, it is critical that the software have the capability to customize the geometry of the devices in three dimensions. Access to such software would save limited funds for other purposes.

We are developing several liquid coating processes, including coating of insulators for filling trenches and coating of liquid containing suspended solids. Expertise on selecting materials and coating parameters would accelerate development of these processes.

We propose to use standard screen printed metallization for both sides of our cell. We also propose to use modern high-efficiency carrier-selective contacts. These contacts require specific metal inks to form ohmic contact. While companies and academic researchers have reported high-efficiency cell results with screen-printed contacts, they have not reported the ink formulations or suppliers they used. Connecting to members of the American Made Network who know what inks have been used successfully with our proposed buffer layers would accelerate our efforts to identify ink suppliers and test their products. We also currently do not have an automated screen printer and have performed our experiments to date printing manually. Access to a screen printer would afford more control of the screen printing process, allowing us to determine the best ink and printing process faster. We have access to rapid thermal processing through shared user facilities at Stanford and UC Berkeley. However, access to a tool where the process parameters for standard firing profiles of screen-printed metallization is already known would accelerate process development.

Optimizing ARC thickness, possibly as a function of position on our devices will be critical to achieving our milestones for absorption and high efficiency. PECVD SiNx or sputtered ITO are options for this layer. We can deposit these materials at shared use facilities at Stanford or UC Berkeley, but access to a tool where the deposition parameter space is well-characterized with regard to deposition rate (film thickness) and the optical properties (e.g., complex refractive index) of the films would accelerate development.

The processes we are developing require a range of characterization to link process variables to performance metrics, and to link both to underlying structural properties (morphology, chemical composition, etc.). Specifically, we need access to:

- High-resolution mapping of minority carrier lifetime;
 - High-resolution surface photovoltage to distinguish the effects on surface lifetime of chemical passivation (density of unpassivated silicon dangling bonds at the surface) and field effect passivation (the size of the depletion region near the surface);
- High-resolution mapping of the chemical composition and thickness of thin films;
- High-resolution mapping of shunt resistance;
- High-resolution measurements of local contact resistance;
- Measurements of grain size, orientation, and dislocation density in silicon.

We have had preliminary discussions with Dr. Shaul Aloni at LBNL and submitted a proposal to use the equipment at LBNL's Molecular Foundry, which includes:

- High-resolution photoluminescence mapping, including two-photon measurements that can be used to separate bulk and surface lifetime;
- AFM with Kelvin probe surface potential mode;
- SEM with EDS, Nano-Auger spectroscopy;
- Microprobe station;
- XRD and EBSD;

NREL also has characterization tools for these measurements. The local geometry of our devices requires non-standard analysis of the data from several of these tools, including photoluminescence and surface photovoltage. Assistance from national lab staff scientists would accelerate the development of these analytical techniques.

For our Go! Demo, we intend to develop several additional processes. These include amorphous silicon passivation and carrier transport layers. These layers are known to have relatively narrow process windows for excellent performance with regard to layer thickness, density, and specific chemical composition (determined by process variables like temperature, pressure, gas composition and flow rate that can often vary from tool to tool and by position within a single tool). A tool where the relationship between process parameters and performance in PV cells is well-characterized would shorten development time for this process. Amorphous silicon buffer layers are also known to be sensitive to the state of the surface immediately before deposition. Knowledge of surface preparation procedures that can lead to high efficiency contacts on a given tool would also accelerate development.

We also want to develop silicon and SiO₂ etches with submicron control of the etch depth. A reactive ion etch or wet etch could be effective, but our substrates will be metallized (though the metallization will be coated with non-metal), and the surface exposed by the etch needs to remain uncontaminated. We can develop this process on shared tools at Stanford or Berkeley, but a tool with established processes and appropriate levels of cleanliness control would shorten development time.

Finally, there are several non-scalable processes, like a photolithographically-defined evaporated front metal grid that could accelerate our path to our first prototype but would be prohibitively slow to develop in-house.