SLAC-TN-15-067

Alison Ong
August 20, 2015

Investigating the Effect of Pyridine Vapor Treatment on Perovskite Solar Cells
Abstract for a General Audience

Solar power is an important and increasingly widespread form of renewable energy. If you've ever seen solar panels on someone's roof, they are probably made with crystalline silicon. However, the possibility of creating cheaper and more efficient solar cells motivates scientists to continue searching for alternative materials. Perovskites are one of the newest and most promising solar cell materials: they have seen incredible efficiency gains in just a few years, jumping from 3.8% in 2009 to over 20% in 2014. Even though there's been progress in improving perovskite-based device efficiency, there are many fundamental aspects of perovskite formation that are still not fully understood. The overall aim of my research is to study these processes and help fill in some of the knowledge gaps.

Making perovskites is like baking cookies. First, we mix the ingredients together; in this case, a solution of methylammonium iodide with lead chloride is prepared. Second, we "roll out the dough" by creating a thin film using spin coating. Third, we bake the raw material to get the finished product, which means annealing the samples on a hot plate. And as with cookies, the temperature and length of time you "bake" them for makes a big difference. While many people are researching perovskites, the annealing conditions reported are inconsistent. I investigated various annealing times and temperatures to try and pinpoint the conditions that formed the best perovskite. I used a technique called x-ray diffraction to analyze my data, which is like studying a chocolate chip cookie to see the position and quantity of chocolate chips present. I concluded that annealing at 100°C for 90 minutes followed by 120°C for 15 minutes was the most effective.

Sometimes, you eat one of the cookies you made and find that it could taste better. If there was something you could do to cookies after baking them to make them tastier, you'd improve the overall quality of your batch. Similarly, we would like to use post-processing treatments to further enhance perovskite efficiency. Using pyridine vapor was previously shown to improve perovskite carrier lifetime and film homogeneity, but the reasons for this phenomenon are unclear. I conducted three tests to better understand the effect of pyridine vapor treatment. First, we performed Time-Resolved Photoluminescence Lifetime testing, which is like seeing how long it is before the cookies go stale. Second, we tested the UV-Vis Spectroscopy, which is analogous to adding sugar until you determine a cookie's tastiness threshold. And third, we did x-ray diffraction on the treated samples again. We found that the effects of pyridine are more complex than originally thought: while it does seem to make the film more homogenous, it also has other effects. Pyridine decreases overall PL lifetime, narrows the perovskite's bandgap, gives rise to a more intense perovskite peak, and results in introduction of an unknown species in the perovskite film. As with any good baking experiment, this summer's research has taught us a lot about how to make better perovskite, and how pyridine vapor may be helpful in enhancing perovskite efficiency.

SLAC National Accelerator Laboratory, 2575 Sand Hill Road, Menlo Park, CA 94025
This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists (WDTS) under the Science Undergraduate Laboratory Internship (SULI) program, under Contract No. DE-AC02-76SF00515.