Chemical Processing of Solar Cells

Tim Anderson
Chemical Engineering Department
University of Florida

The increasing cost of energy and the rapidly decreasing price of solar cells have made this industry one of the fastest growing sectors in the world economy. Although current commercial production of photovoltaic (PV) modules is largely based on crystalline Si, next generation thin-film devices are being developed with the promise of significantly lower costs. In particular, $Cu(InGa)Se_2$ (CIGS), CdTe, and amorphous Si cells have advanced considerably during the past several years. More recently, cells that involve organic materials and nanoparticles have emerged on the research front. This presentation will give an overview of the various technologies that are promising for commercial PV as well as illustrate specific processing challenges to producing CIGS cells.

This talk will primarily focus on thin film technologies as they are now being rapidly commercialized. Most thin film technologies are differentiated on the basis of how they synthesize the absorber. A variety of deposition techniques have been demonstrated and the processes optimized to maximize cell efficiency. Thus, a prudent near term strategy to cost reduction is to increase the absorber synthesis rate and scale-up the existing process, hopefully retaining cell performance. For many processes the synthesis step is not limited by the rate of deposition of the materials, but rather it is limited by the rate of reaction to synthesize the absorber material.

Another near term strategy to decreasing costs is the obvious gains from increasing the scale of the manufacturing process. Scaling production capacity can be accomplished by either replication (building more identical process lines) or by increasing the individual process size (e.g., wider web). This latter approach has well documented advantages, but the scaling laws are not obvious and this adds risk. Since many thin film companies will significantly increase their production capacity in the near term, a better understanding of how to scale their process is critical.

In particular, the advances that have been made in the performance and fabrication of $Cu(InGa)Se_2$ (CIGS) cells during the past several years have made this material system the leading candidate for second generation thin-film technology. The high absorption coefficient, ability to bandgap engineer the absorber layer, a favorable point defect chemistry, and textured microstructure contribute to the attractiveness of CIGS. Another part of the reason for the rapid development of CIGS thin-film technology is the discovery of a variety of reaction pathways that lead to efficient absorber layer formation (e.g., co-deposition of elements, stacked elemental layer, and direct compound formation). The opportunities for chemical engineering of solar cells will be illustrated for this system.