Characterization plays a key role in developing a comprehensive understanding of the structure and performance of photovoltaic devices. High quality characterization methods enable researchers to assess material choices and processing steps, ultimately giving way to improved device performance and reduced manufacturing costs. In this work, several aspects of advanced metrology for crystalline silicon photovoltaics are investigated including in-line applications for manufacturing, off-line applications for research and development, and module/system level applications to evaluate long-term reliability.

A framework was developed to assess the cost and potential value of metrology within a manufacturing line. This framework has been published to an on-line calculator in an effort to provide the solar industry with an intuitive and transparent method of evaluating the economics of in-line metrology. One important use of metrology is in evaluating spatial non-uniformities, as localized defects in large area solar cells often reduce overall device performance. Techniques that probe spatial uniformity were explored and analysis algorithms were developed that provide insights regarding process non-uniformity and its impact on device performance. Finally, a comprehensive suite of module level characterization was developed to accurately evaluate performance and identify degradation mechanisms in field deployed photovoltaic modules. For each of these applications, case-studies were used to demonstrate the value of these techniques and to highlight potential use cases.