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The Integration of Scanning Electron Microscopy, Scanning Probe Microscopy, and Luminescence Spectroscopy in one Platform: New Opportunities and Applications in Photovoltaics

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We have recently integrated scanning tunneling microscopy (STM), atomic force microscopy (AFM), and near-field scanning optical microscopy (NSOM) onto the mechanical stage of a scanning electron microscope compatible with operation under high vacuum and the use of cryogenics. This instrument is unique in the sense that is not just the assembly of different microscopes but an integrated platform in which both the electron beam and the ultrasharp tip of the AFM/STM/NSOM can be controlled simultaneously and independently as excitation or sensing elements, providing innovative modes of operation and access to optoelectronic properties in the micro and nanoscale not accessible before. Furthermore, this instrument is equipped with focused laser illumination of the tip and detection of luminescence and can be used to measure cathodoluminescence, scanning tunneling luminescence, photoluminescence, and electroluminescence, all with high resolution. In this contribution, we review the application of these techniques to the development of second- and third-generation photovoltaics (PV) beyond those commercially available today. Among these applications, we present the luminescence and electron transport across single grain boundaries in chalcopyrite and kesterite compounds, the detection of single molecule species using plasmonics, the nanoscale imaging of the exciton transport in organic semiconductors, and the insitu manipulation and measurement of nanowires.