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Manufacturing for Terawatt-Scale Energy Applications[1]

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Future energy conversion devices will make extensive use of nanostructured materials that must be manufactured at a scale compatible with terawatt-scale deployment. Specifically, future ultrahigh efficiency photovoltaic devices and modules will likely have little in common with today's photovoltaic technology but instead will be essentially complex optical integrated circuits with microscale and nanoscale critical dimensions for efficient optical spectrum splitting, light absorption and carrier transport. The challenge for nanomanufacturing is to realize the fabrication of these sophisticated device architectures with nanoscale features in high-volume low-cost commodity fabrication processes. I will describe examples of practical and scalable approaches to large-scale nanophotonic fabrication using recent advances in the research and commercial development. One example is epitaxial liftoff of thin-film single-crystal Si and III–V compound semiconductor absorbers, and layer-transfer printing techniques for single crystal film assembly of lifted film structures. Another is substrate conformable soft-imprint lithography provides a scalable method for the synthesis of low-cost large-area arrays of nano-patterned light-trapping structures or structures with engineered optical density of states. It is now well established that soft-imprint lithography has a deep-subwavelength resolution, maintained over a large area. Directions for future research and applications to other energy technologies will be surveyed.

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