effects; (2) discovering the effect of grain boundaries on film properties and junction behavior; and (3) controlling film properties over very large area, encompassing $\sim 10^{12}$ grains per square meter for a CdTe module having 1-μm-wide grains. For CdTe/CdS solar cell development, these challenges have been met through advancing characterization techniques and empirical optimization of film deposition and postdeposition treatments.

A detailed review of the analytical techniques employed to probe the microstructure, microchemistry, and electronic properties of thin-film CdTe/CdS solar cells is beyond the scope of this chapter. However, several powerful methods have emerged to provide a quantitative assessment of film properties and are discussed elsewhere generally [63, 64], and specifically in terms of CdTe/CdS solar cells [65–67]. Some of these methods may ultimately find application as diagnostic sensors for in-line process-control feedback during module manufacture. These are listed below, accompanied by one or more references in which the techniques are applied to CdTe/CdS thin-film solar cells.

Morphology and structure:
- Scanning Electron Microscopy (SEM) [68]
- Transmission Electron Microscopy (TEM) [69]
- Atomic Force Microscopy (AFM) [70]
- X-Ray Diffraction (XRD) [71]

Bulk chemical composition:
- Energy Dispersive X-ray Spectroscopy (EDS) [72]
- X-Ray Diffraction (XRD) [73]
- Auger Electron Spectroscopy (AES) [74]
- Secondary Ion Mass Spectroscopy (SIMS) [75, 76]

Surface chemical composition:
- X-ray Photoemission Spectroscopy (XPS) [77]
- Glancing Incidence X-Ray Diffraction (GIXRD) [78]

Optoelectronic properties:
- Optical absorption [79]
- Ellipsometry [80]
- Raman [81]
- Photoluminescence (PL) [82, 83]

Junction analysis:
- Current–voltage versus illumination and temperature ($J$–$V$–$T$) [28, 84]
- Spectral response [23]
- Capacitance–voltage ($C$–$V$) [85]
- Optical Beam Induced Current (OBIC) [86]
- Electron Beam Induced Current (EBIC) [87]
- Cathode Luminescence (CL) [88]

Numerous methods have been employed to deposit CdTe thin films for solar cells, as detailed in the special issue of the *International Journal of Solar Energy* [89] and other review articles [90–92]. We will review eight methods that have demonstrated viability for the commercial manufacture of CdTe solar cells and modules over the past decade. Figure 14.6 presents schematic views of each fabrication procedure, including nominal temperature and pressure conditions, film thickness, and growth rate. The