

The front-end process consists of four continuous, roll-to-roll steps in separate machines: (1) substrate washing, (2) sputter deposition of the back reflector, (3) a-Si semiconductor deposition, and (4) ITO top electrode deposition. Rolls of magnetic SS web, typically 125  $\mu\text{m}$  thick, 0.35 m wide, and 700 m long, are guided through these roll-to-roll machines by magnetic rollers. The roll is unwound from a modular “payoff” chamber on one side and wound up in a modular “take-up” chamber on the other side. Figure 12.27 is a photo of front-end facilities at an ECD designed 2-MW plant, operated by Sovlux, and showing all four roll-to-roll machines.

In the roll-to-roll washing machine, the SS web is guided through ultrasonic detergent cleaning stations with spinning brushes rubbing the surface, multiple deionized water rinse baths, and an infrared drying chamber. An oil-free, particle-free, clean SS roll is then wound up with protective interleaf.

The roll is then unloaded from the take-up chamber of the wash machine and loaded into the payoff chamber of the back-reflector sputter machine. In this machine, the SS web is pulled through several DC magnetron sputter deposition zones with metal targets (Al, Ag, or other alloys) for the reflective layer and ZnO targets for the deposition of ZnO buffer layer. The substrate is maintained at elevated temperature during sputtering so that the metal films develop a texture useful for optical enhancement [185, 187].

The roll is then loaded into the RF PECVD machine for the continuous roll-to-roll deposition of nine layers of semiconductors (*nip/nip/nip*) as well as all of the buffer layers on both sides of a-SiGe absorber layers. The deposition of the different layers occurs sequentially but in a single pass. Innovative “gas-gate” design allows the manufacturer to isolate the feedstock gases in different chambers and to prevent cross-contamination, while at the same time the web passes through the sequence of chambers continuously. The gas gate utilizes laminar gas flow to effectively isolate the gases in adjacent chambers.



**Figure 12.27** A photograph of the Energy Conversion Devices, Inc. 2-MW plant showing all four front-end roll-to-roll machines for washing, back reflector sputter deposition, PECVD deposition (right-hand side) and TCO deposition [185]