There has been relatively little effort devoted to devices on single-crystal $CuInSe_2$ since this early work, in part because of the difficulty in growing high-quality crystals [12]. Instead, nearly all the focus has gone to thin-film solar cells because of their inherent advantages. The first thin-film $CuInSe_2$/CdS devices were fabricated by Kazmerski *et al.* using films deposited by evaporation of $CuInSe_2$ powder along with excess Se [13]. However, thin-film $CuInSe_2$ solar cells began to receive a lot of attention when the first high-efficiency, 9.4%, cells were demonstrated by Boeing [14]. At the same time, interest in Cu_2S/CdS thin-film solar cells waned owing to problems related to electrochemical instabilities and many of these researchers turned their focus to $CuInSe_2$.

The Boeing devices were fabricated using $CuInSe_2$ deposited by coevaporation, that is, evaporation from separate elemental sources [15], onto ceramic substrates coated with a Mo back electrode. Devices were completed with evaporated CdS or (CdZn)S deposited in two layers with undoped CdS followed by an In-doped CdS layer that served as the main current-carrying material [15]. Throughout the 1980s, Boeing and ARCO Solar began to address the difficult manufacturing issues related to scale-up, yield, and throughput leading to many advancements in $CuInSe_2$ solar cell technology. The two groups pursued different approaches to $CuInSe_2$ deposition, which today remain the most common deposition methods and produce the highest device and module efficiencies. Boeing focused on depositing Cu(InGa)Se_2 by coevaporation, while ARCO Solar focused on a two-stage process of Cu and In deposition at a low temperature followed by a reactive anneal in H_2Se.

The basic solar cell configuration implemented by Boeing provided the basis for a series of improvements that have lead to the high-efficiency device technology of today. The most important of these improvements to the technology include the following:

- The absorber-layer band gap was increased from 1.02 eV for $CuInSe_2$ to 1.1–1.2 eV by the partial substitution of In with Ga, leading to a substantial increase in efficiency [16].
- The 1- to 2-μm-thick doped (CdZn)S layer was replaced with a thin, $\leq$50 nm, undoped CdS and a conductive ZnO current-carrying layer [17]. This increased the cell current by increasing the short wavelength (blue) response.
- Soda lime glass replaced ceramic or borosilicate glass substrates. Initially, this change was made for the lower costs of the soda lime glass and its good thermal expansion match to $CuInSe_2$. However, it soon became clear that an increase in device performance and processing tolerance resulted primarily from the beneficial indiffusion of sodium from the glass [18].
- Advanced absorber fabrication processes were developed that incorporate band gap gradients that improve the operating voltage and current collection [19, 20].

From its earliest development, $CuInSe_2$ was considered promising for solar cells because of its favorable electronic and optical properties including its direct band gap with high absorption coefficient and inherent *p*-type conductivity. As science and technology developed, it also became apparent that it is a very forgiving material since (1) high-efficiency devices can be made with a wide tolerance to variations in Cu(InGa)Se_2 composition [21, 22], (2) grain boundaries are inherently passive so even films with grain sizes less than 1 μm can be used, and (3) device behavior is insensitive to defects at the junction caused by a lattice mismatch or impurities between the Cu(InGa)Se_2 and