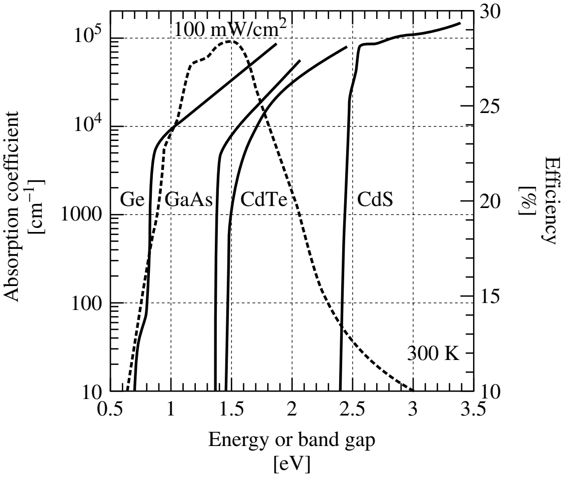

Figure 14.1 Theoretical solar cell efficiency (dotted) for AM1.5 spectral irradiance versus band gap and absorption coefficient (solid) versus energy for different semiconducting photovoltaic materials

CdTe emerged as a new electronic material in 1947 when Frerichs synthesized CdTe crystals by the reaction of Cd and Te vapors in a hydrogen atmosphere and measured their photoconductivity [3]. The early foundation for understanding the electronic nature of CdTe emerged from subsequent studies of single crystals purified by zone refinement. In 1954, Jenny and Bube [4] first reported that p-type and n-type conductivity could be obtained in CdTe by doping with foreign impurities. Shortly thereafter, Krüger and de Nobel [5] showed that the conductivity type could also be changed by varying the Cd–Te stoichiometry. Cd excess yields n-type and Te excess yields p-type conductivity, as had been discovered for PbS, PbSe, and PbTe. In 1959, the $p{-}T{-}x$ diagram of the Cd–Te system and its relationship to intrinsic conduction and extrinsic conductivity via foreign-atom incorporation was established by de Nobel [6], who proposed the existence of two electronic levels associated with Cd vacancies and one with interstitial Cd to account for the measured changes in conductivity at different temperature and Cd partial pressure. Furthermore, the electronic levels associated with In as an n-type dopant and Au as a p-type dopant were estimated.

Loferski at RCA first proposed using CdTe for photovoltaic solar energy conversion in 1956 [1]. Although methods for controlling n and p-type conductivity in CdTe crystals were established by 1960, limited research was directed at the development of p/n homojunctions. In 1959, Rappaport, also at RCA, demonstrated single-crystal homojunction CdTe cells with conversion efficiency ~2% fabricated by diffusion of In into p-type CdTe crystals, yielding $V_{OC} = 600$ mV, $J_{SC} \sim 4.5$ mA/cm^2 (73 mW/cm^2 irradiance), and fill factor (FF) = 55% [7]. In 1979, the CNRS group in France achieved >7% conversion efficiency for a device made by close-space vapor transport deposition (VTD) of p-type arsenic-doped CdTe films onto n-type crystals, with $V_{OC} = 723$ mV, $J_{SC} \sim 12$ mA/cm^2 (AM1 irradiance) and $FF = 63\%$ [8]. Later they reported cells with efficiency >10.5%, with $V_{OC} = 820$ mV, $J_{SC} = 21$ mA/cm^2, and $FF = 62\%$ [9]. Little subsequent work on p/n CdTe homojunctions has been reported.