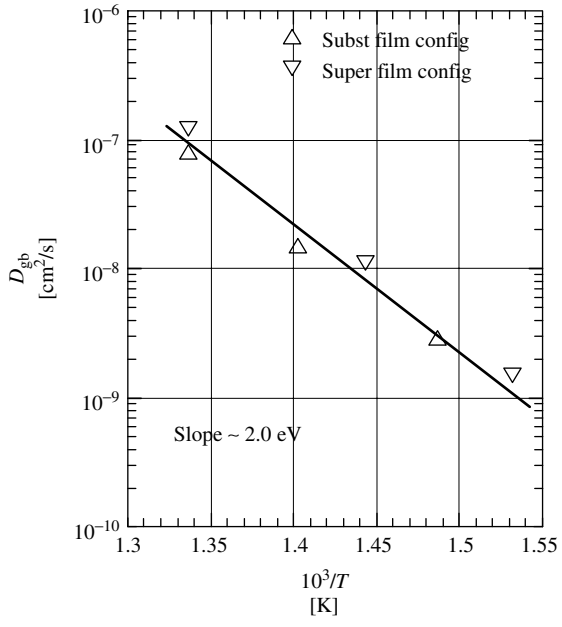

Figure 14.17 Arhennius plot of grain-boundary diffusion coefficients versus inverse of treatment temperature for values obtained by modeling XRD line profiles of thin-film CdTe/CdS samples [73]

In cells, alloy formation has both beneficial and detrimental effects. The interdiffusion process narrows the absorber-layer band gap, resulting in higher long-wavelength quantum efficiency. Although this gain is somewhat offset by a reduction in the built-in voltage, open-circuit voltages exceeding 820 mV have been obtained in cells having alloyed $CdTe_{1-x}S_x$ absorber layers with composition $x > 0.05$, made by spray pyrolysis [150]. Intermixing reduces interfacial strain [68] and may reduce the dark recombination current [78]. The CdS film thickness is reduced, which can be beneficial for window transmission, but nonuniform CdS consumption can result in lateral junction discontinuities. The $CdTe_{1-x}S_x$ alloy formation is detected in XRD line profiles of the absorber layer and in the long-wavelength spectral response. This correlation between compositionally broadened XRD line profiles and the long-wavelength QE edge is illustrated in Figure 14.19 for XRD and QE measurements of completed cells. For CSS cells, deposited at high temperature and having large grains, the absorber layer exhibits a narrow (511)/(333) XRD profile at the CdTe position, indicating a negligible degree of alloy formation, and hence low CdS diffusion into CSS-deposited CdTe. This is seen in the QE plot, where the long-wavelength edge occurs at the wavelength expected for CdTe. In contrast, the cell made by spray pyrolysis, with the CdTe film formed at high temperature in the presence of $CdCl_2$, exhibits an asymmetrical XRD line profile with its peak near the one expected for the $CdTe_{0.96}S_{0.05}$ and a tail extending toward pure CdTe. The XRD line profile thus indicates nonuniform S distribution in the absorber layer, evident in the QE plot as a shallow drop in the long-wavelength response. The PVD case is intermediate to the CSS and spray cases, having smaller grains than CSS films and receiving less exposure to $CdCl_2$ than sprayed films. Thus, it appears that apart