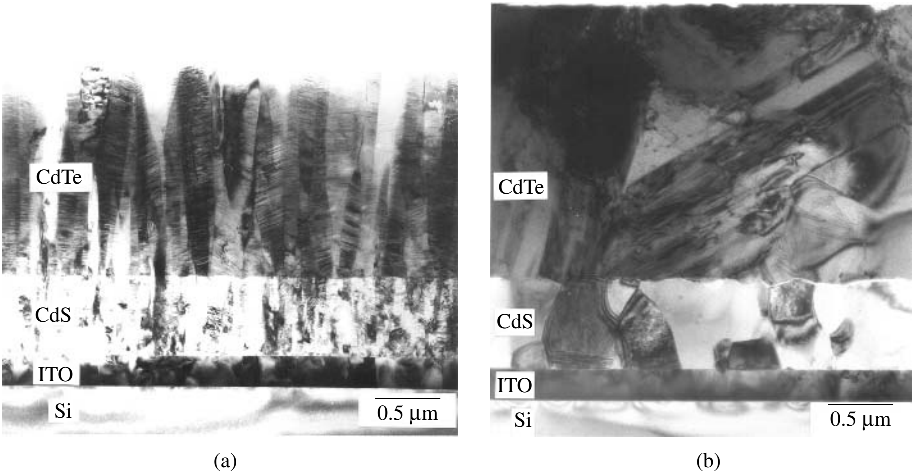

(a) (b)

Figure 14.9 TEM images comparing PVD CdTe/CdS thin-film structures (a) before and (b) after $CdCl_2$ heat treatment at 420°C for 20 min. Average grain size increased from roughly 0.1 to 0.5 μm in both CdTe and CdS

Table 14.2 Structural changes of $CdCl_2$ HT on CdTe deposited by different methods. Data from films examined by B. E. McCandless. For sprayed and screen-printed cells, random film orientation is obtained as a result of the film formation process

Deposition method	Film thickness [μm]	Mean grain size: D Init → $CdCl_2$ HT [μm]	Orientation Init → $CdCl_2$ HT
PVD	4	0.1 → 1	(111) → (220)
ED	2	0.1 → 0.3	(111) → (110)
Spray	10	10 → 10	Rand
Screen	12	∼10	Rand
VTD	4	4 → 4	Rand → Rand
CSS	8	8 → 8	Rand → Rand
Sputter	2	0.3 → 0.5	(111) → (?)
MOCVD	2	0.2 → 1	(111) → Rand

pushed closer to the band edges, resulting in a single, relatively shallow acceptor state. Although this complex is a more effective dopant than the Cd vacancies alone, excess Cl can lead to compensating Cl_{Te} donors.

The impact of $CdCl_2$ treatment on cell operation is increased photocurrent and open-circuit voltage, and reduced shunting. Figure 14.11 compares the light $J-V$ behavior of three PVD cells having 4-μm-thick CdTe and 0.2-μm-thick CdS, processed with the same back contact but with no postdeposition treatment, air-heat treatment at 550°C, and optimized $CdCl_2$ treatment at 420°C for 20 min in air. With no treatment, the device exhibits very low photocurrent and high series resistance. The spectral response is low