dilution of silane by hydrogen (in plasma deposition) causes a change in the optical band gap for a-Si:H films over at least the range 1.6 to 1.8 eV [51]; these changes can be ascribed to changes in the hydrogen microstructure of the films. Even larger changes can be effected by alloying with additional elements such as Ge, C, O, and N; alloying is readily accomplished by mixing the silane (SiH_4) source gas with gases such as GeH_4, CH_4, O_2 or NO_2, and NH_3, respectively. The resulting alloys have very wide ranges of band gaps, as we illustrate for a-$Si_{1-x}Ge_x$:H in Figure 12.10. For simplicity, we shall usually refer to these alloys using the abbreviated notation: a-SiGe for a-$Si_{1-x}Ge_x$:H, and so on.

Only some of these materials have proven useful in devices. In particular, a-SiGe alloys with optical gaps down to about 1.45 eV are employed as absorber layer in multi-junction *pin* cells; the narrower band gap of a-SiGe compared to a-Si allows for increased absorption of photons with lower energies [52]. Figure 12.10(a) illustrates how the spectrum of the absorption coefficient $\alpha(h\nu)$ changes for a-SiGe alloys with different atomic percentages x; the different optical band gaps are indicated as labels. Two features of these data should be noted. First, the Urbach slopes remain constant (at about 50 meV) over the entire range of band gaps. Second, the plateau in the absorption coefficient at the lowest photon energies increases steadily as the band gap diminishes, which is indicative of a corresponding increase in defect density.

Figure 12.10(b) is a contour plot showing how the optical band gap of a-$Si_{1-x}Ge_x$:H varies with the Ge-ratio x and with atomic fraction h of hydrogen. The figure reflects experimental results for a-Si:H alloys of varying H-fraction [51] and for a-SiGe:H alloys for which both x and h were reported [53].[5] Note that, for constant fraction h, the band

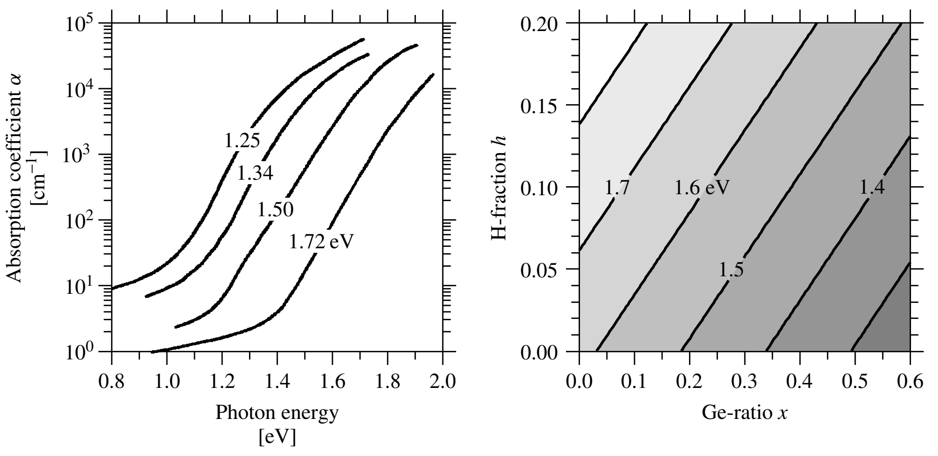

Figure 12.10 (a) Absorption coefficient spectra for a-SiGe alloys; the optical band gaps and corresponding Ge fractions x are 1.25 to 0.58, 1.34 to 0.48, 1.50 to 0.30, 1.72 to 0.0 [52]. (b) Typical optical band gaps for a-$Si_{1-x}Ge_x$:H alloys for varying Ge-ratio x and atomic fraction h of hydrogen

[5] Figure 12.10 is based on the function $E_G = 1.62 + 1.3h - 0.7x$ obtained by fitting to experimental results reported by Hama *et al.* [51] and Middya *et al.* [53].