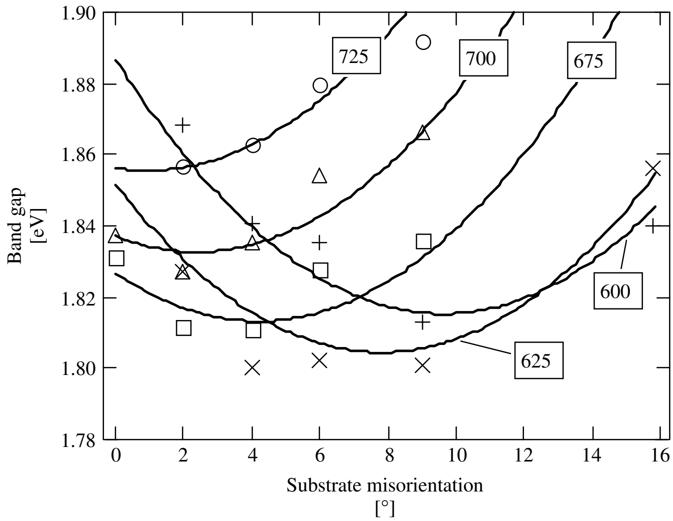

Figure 9.14 Band gap of $Ga_xIn_{1-x}P$ versus T_g (from 600 to 725°C) and substrate misorientation

P_{PH3}, is closer to 1.8 eV than 1.9 eV. One can obtain band gaps closer to 1.9 eV using extreme values for T_g, R_g or P_{PH3}, but the material typically suffers in some other way, for example, minority-carrier diffusion length, composition, or morphology. The most straightforward way to obtain higher band gaps is by using substrates that are strongly misoriented from (100) toward {111}. The {111} surface in the zinc blende system is the Group III terminated surface and is often referred to as (111)A. Substrates misoriented towards (111)B generally enhance the degree of ordering. When growing on Ge there is no distinction between A and B misoriented substrates, and it is typically very difficult to control the A/B character of the III-V (GaAs or GaInP) epilayer. Hence, the easiest way to obtain high band gap GaInP on Ge is to use misorientation angles larger than about 15°, coupled with high R_g, moderate T_g, and low P_{PH3}.

There are other material properties that are affected by ordering, including optical anisotropy [48–51], transport anisotropy [52, 53], and surface morphology [54, 55].

9.6.3.2.2 Absorption coefficient

For modeling and characterization of GaInP epilayers and solar cells, accurate models for the optical properties of GaInP are required. The optical constants of GaInP have been measured by using spectroscopic ellipsometry and modeled by several groups [56, 57] and by using transmission measurements by Kurtz *et al.* [10]. These results are summarized in Figure 9.15. For the most part, there is no single model that adequately describes the broadband optical properties of lattice-matched GaInP with some arbitrary degree of ordering. The model of Kato [57] appears adequate for short wavelengths but fails for near-gap optical properties. The models of Schubert and Kurtz only account for near band gap transitions. The model of Kurtz *et al.* for the absorption coefficient is given by:

$$\alpha = 5.5\sqrt{E - E_g} + 1.5\sqrt{E - (E_g + \Delta_{so})}[\mu m^{-1}] \qquad (9.22)$$