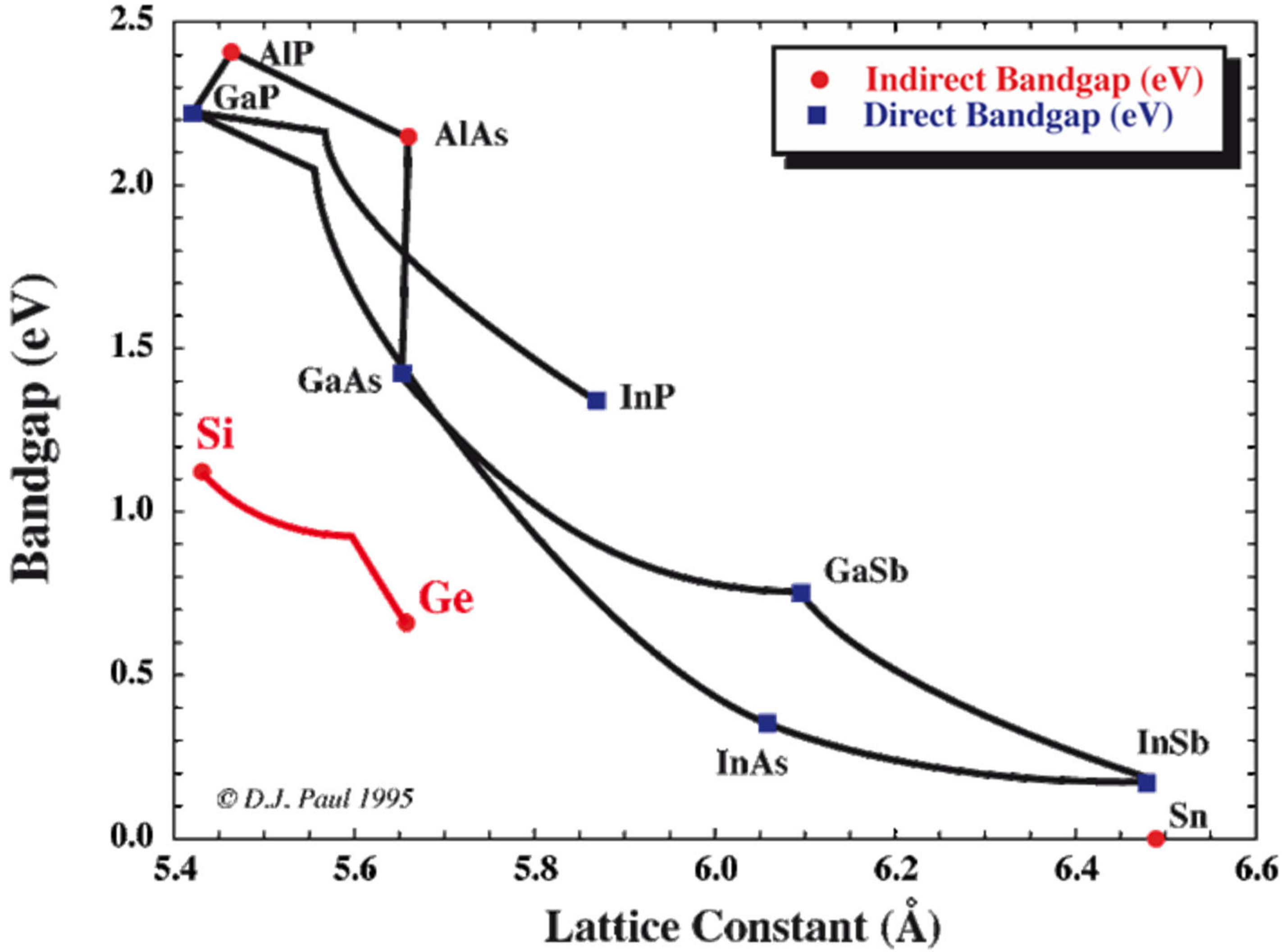
Ordering and clustering in thin films

Why should we try to grow more complicated compounds?



Why should we try to grow more complicated compounds?

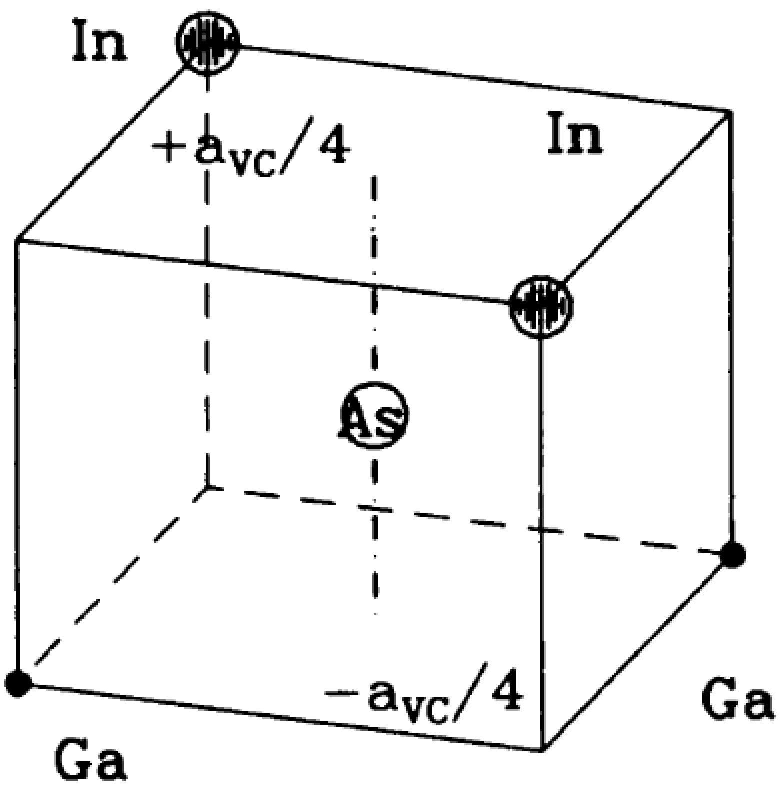
Table 1
Summary of III/V alloys: $A_xB_{1-x}C_yD_{1-y}$

System	Applications	Critical temperature (calc.) (°C)	Experimental observations
$Ga_xIn_{1-x}As_yP_{1-y}$	IR emitters and detectors, FETs	827	Miscibility gap detected at 670°C
$Al_xGa_{1-x}As_ySb_{1-y}$	Tandem solar cells, DH lasers, (1–1.8 μm), photodiodes, IR LEDs	691 [a]	Miscibility gap of unknown proportions
$Ga_xIn_{1-x}As_ySb_{1-y}$	LEDs and lasers 1.8–4.0 μm, low noise FETs	1188	Miscibility gap
$Al_xGa_{1-x}As_yP_{1-y}$	Perfectly lattice matched lasers ($y \approx 1$)	−38	–
$Al_xGa_{1-x}P_ySb_{1-y}$	–	1832 [a]	–
$Al_xIn_{1-x}As_yP_{1-y}$	–	761	–
$Al_xIn_{1-x}As_ySb_{1-y}$	–	1410	–
$Al_xIn_{1-x}P_ySb_{1-y}$	–	2477	–
$Ga_xIn_{1-x}P_ySb_{1-y}$	–	2269	–

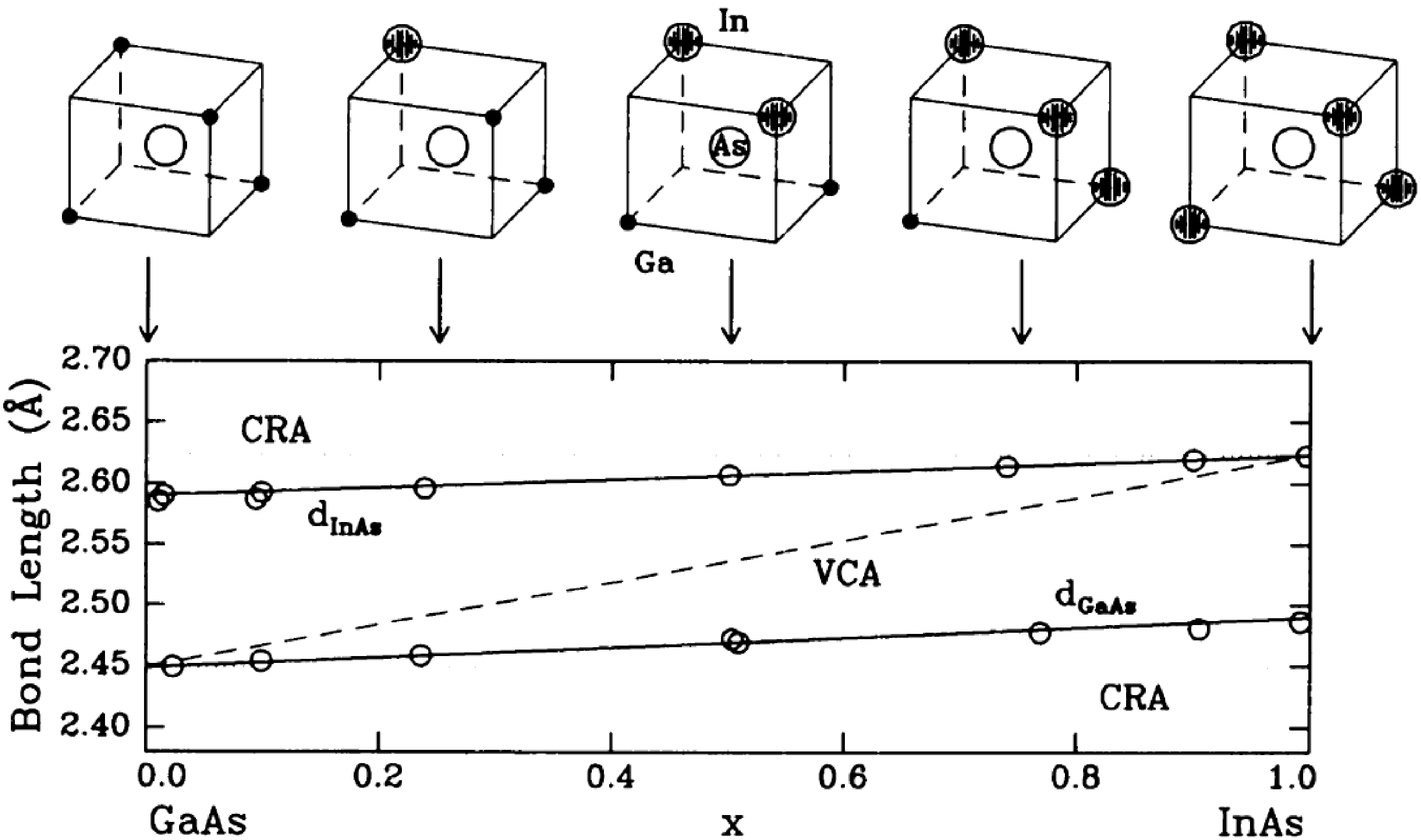
[a] Calculated for highest T_c ternary since $\Delta a_A \approx 0$, $\Delta a_C \gg 0$.

G.B. Stringfellow , J. Cryst. Growth 58, 194 (1982)

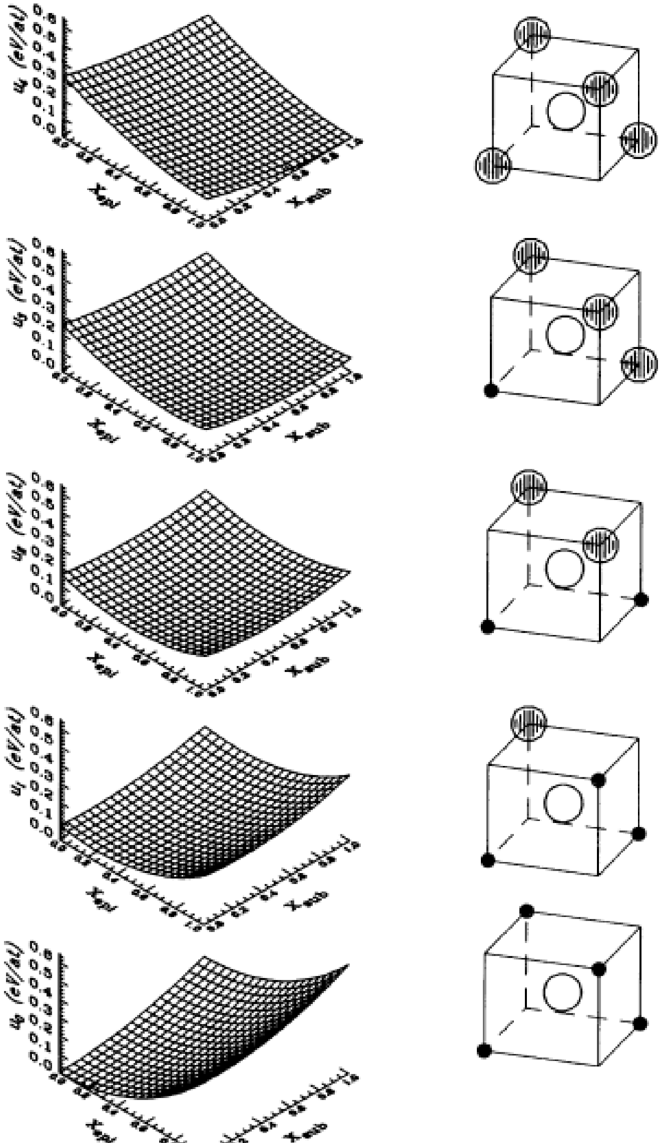
Example of InGaAs



Example of InGaAs



Energy of the various types of tetrahedra as a function of composition



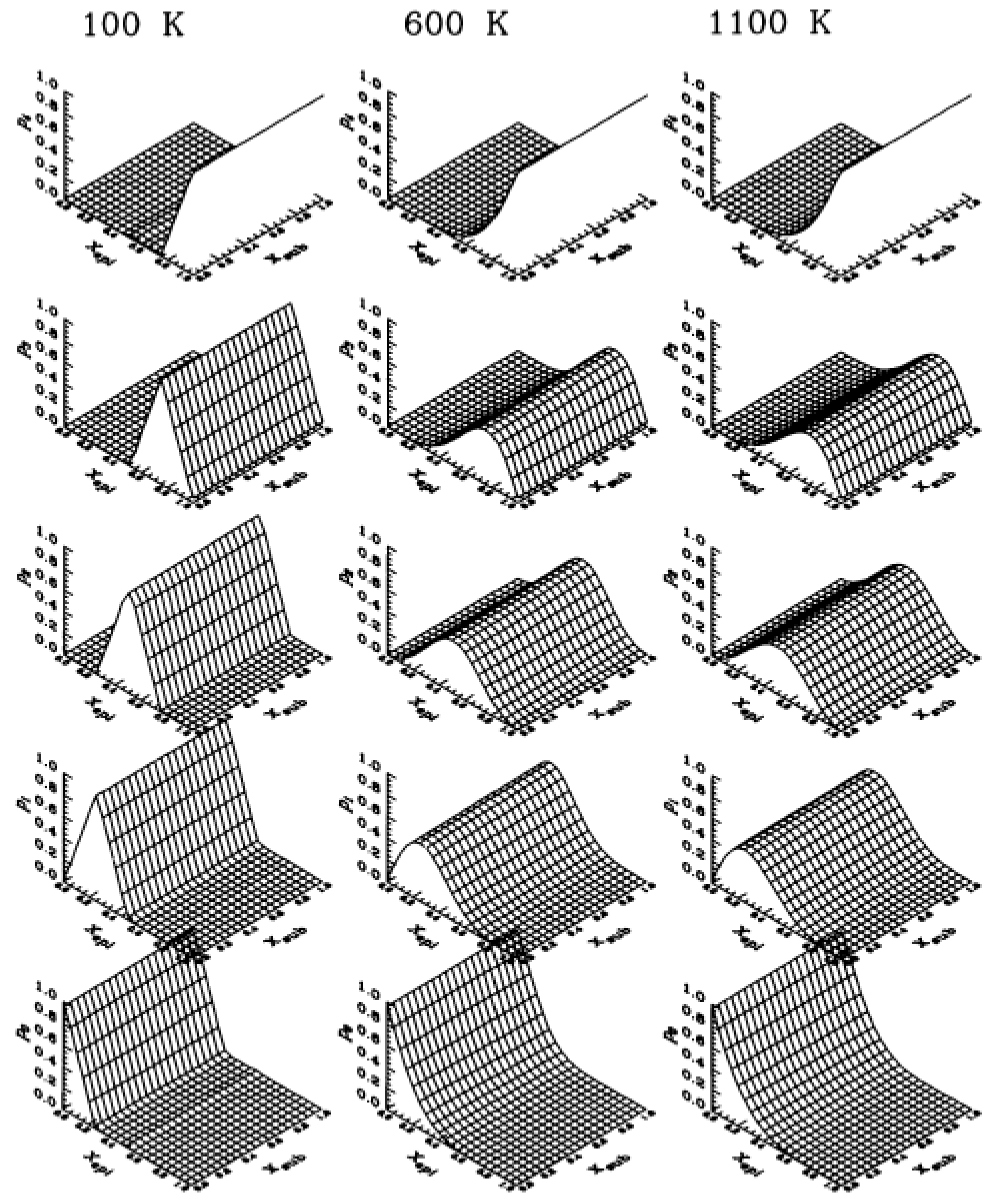
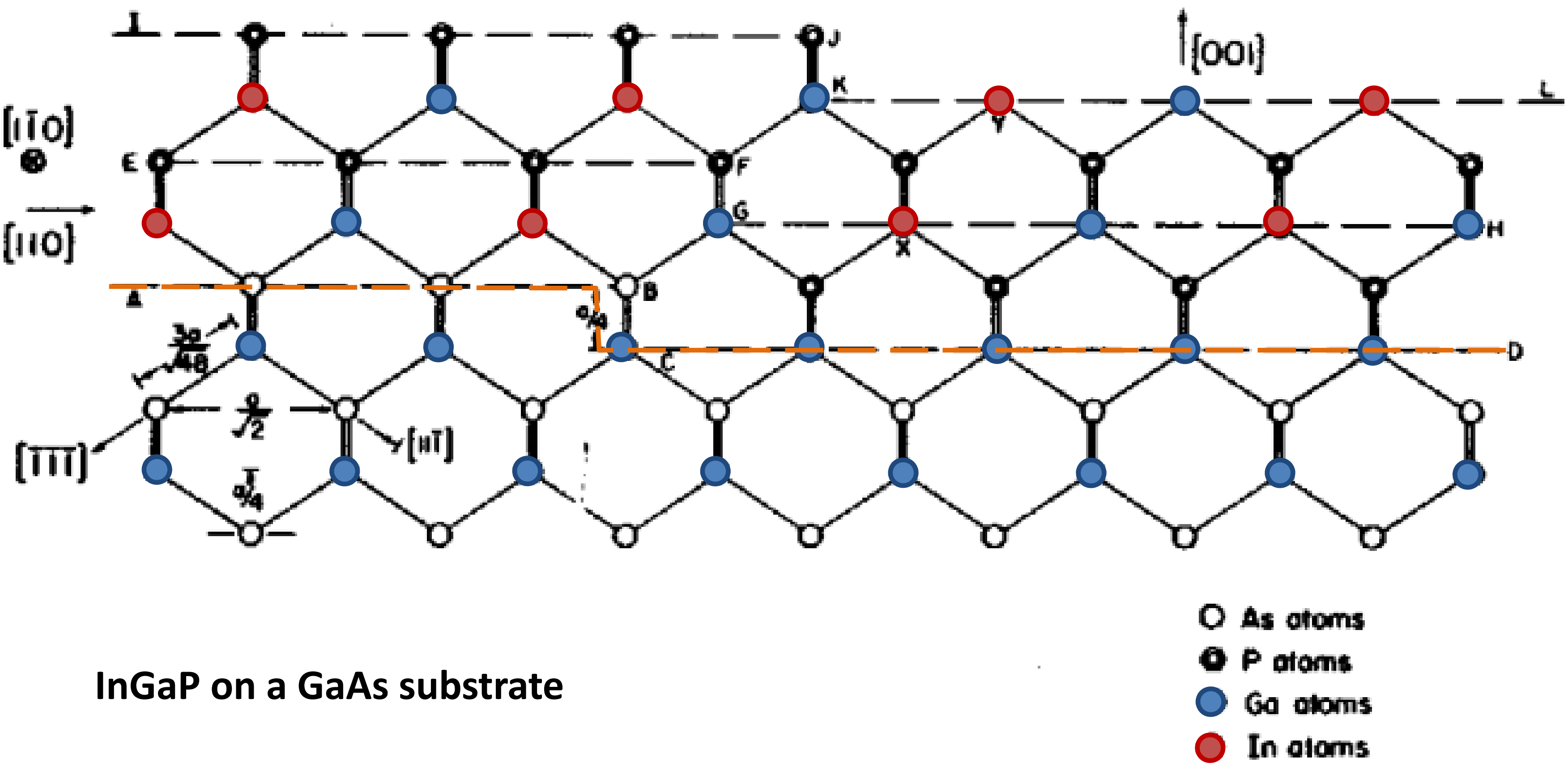


Figure 4.12: 100, 600, or 1100 K probabilities of various tetrahedra embedded in $In_{1-x}Ga_xAs$ of composition x_{epi} grown coherently on substrates having the lattice parameters of bulk $In_{1-x}Ga_xAs$ at composition x_{sub}.

Ordering within the ternary alloy



InGaP on a GaAs substrate

S. Mahajan, M.A. Shahid, D.E. Laughlin, Inst. Phys. Conf. Ser nr 100 3 (1989)

Ordering in ternary and quaternary alloys manifested by diffraction

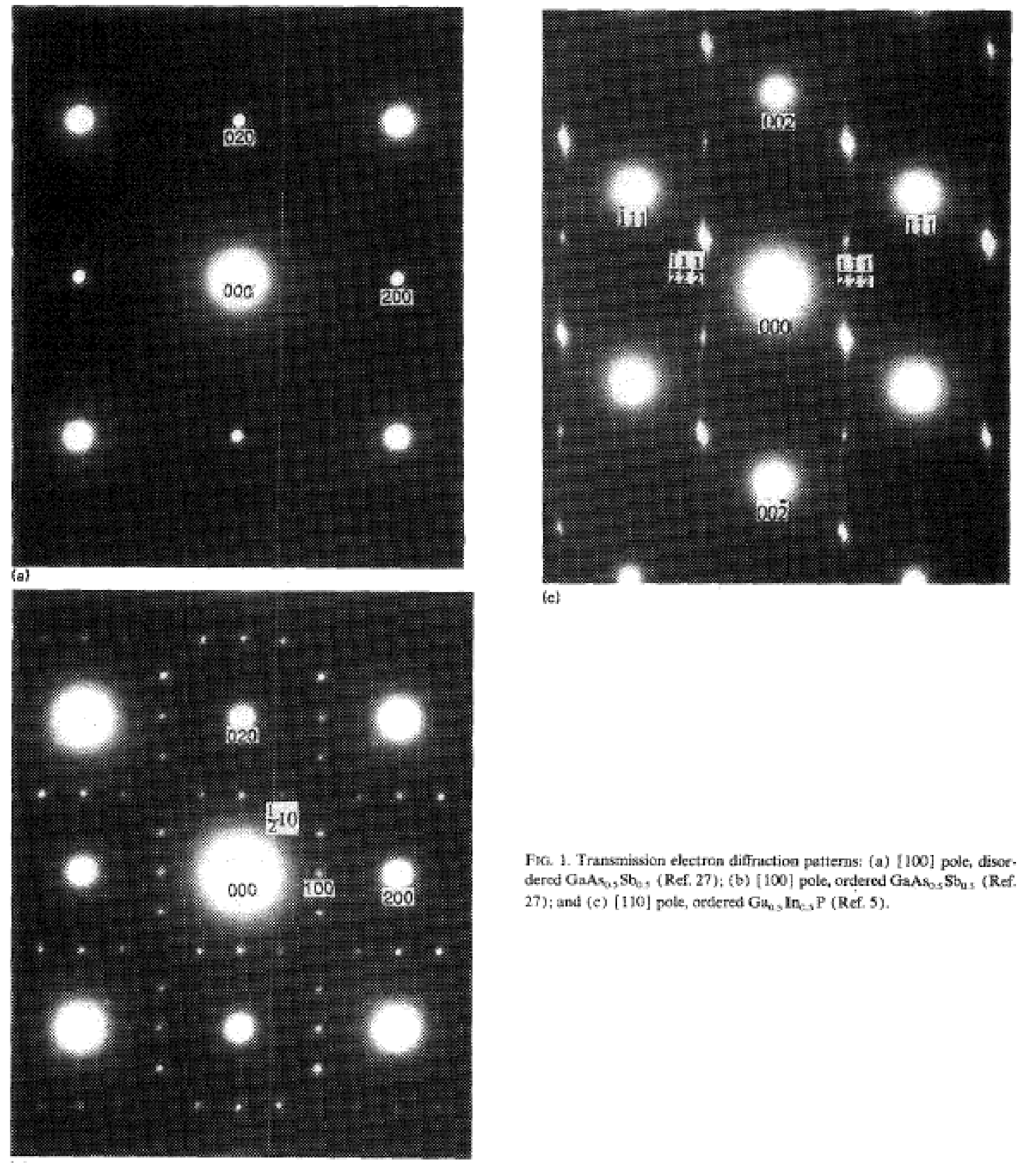


FIG. 1. Transmission electron diffraction patterns: (a) [100] pole, disordered $GaAs_{0.5}Sb_{0.5}$ (Ref. 27); (b) [100] pole, ordered $GaAs_{0.5}Sb_{0.5}$ (Ref. 27); and (c) [110] pole, ordered $Ga_{0.5}In_{0.5}P$ (Ref. 5).

Stringfellow et al,
J.Sci.Vac.Technol. B (1991)

Ordering in ternary and quaternary alloys manifested by diffraction

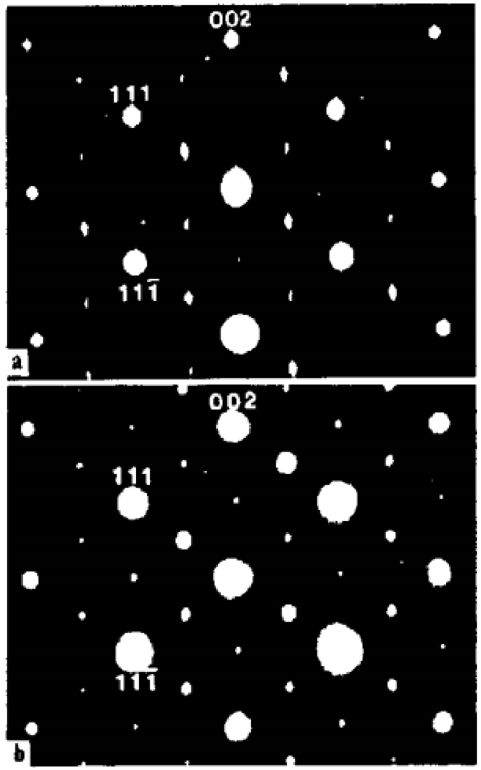


Fig. 1. Electron diffraction patterns observed from (Ga, Al)InP layers grown at (a) high, and (b) low growth rate. Note the presence of diffuse intensity bands in (a) that are parallel to the [001] growth direction and pass through superlattice reflections.

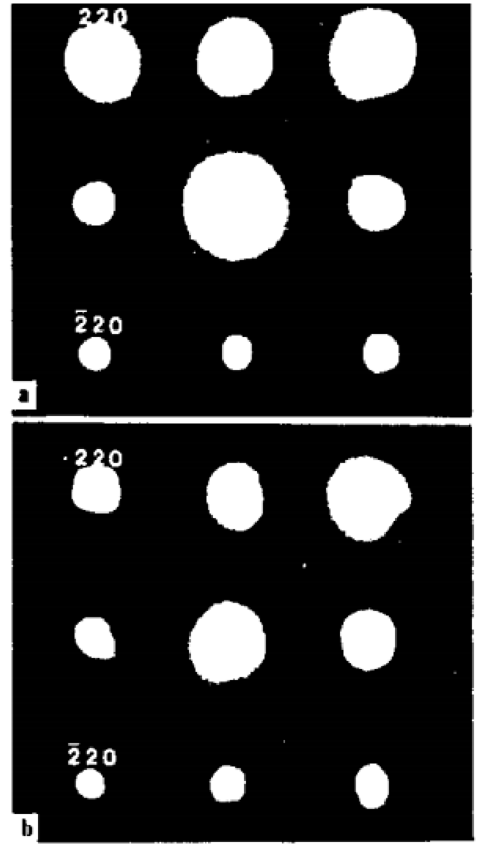


Fig. 2. Electron diffraction patterns observed from (Ga, Al)InP layers grown at different temperatures and growth rates on (001) GaAs substrates by low pressure OMVPE: (a) growth temperature is 650° C and growth rate is 1.08 μm/hr., and (b) growth temperatrue is 680° C and growth rate is 0.67 μm/hr. Note that in addition to the spots of the zinc-blende structure, extra spots occur at ± (1/2, 1/2, 0) and equivalent positions in (a) and (± 1, ± 1, 0) and equivalent positions in (b).

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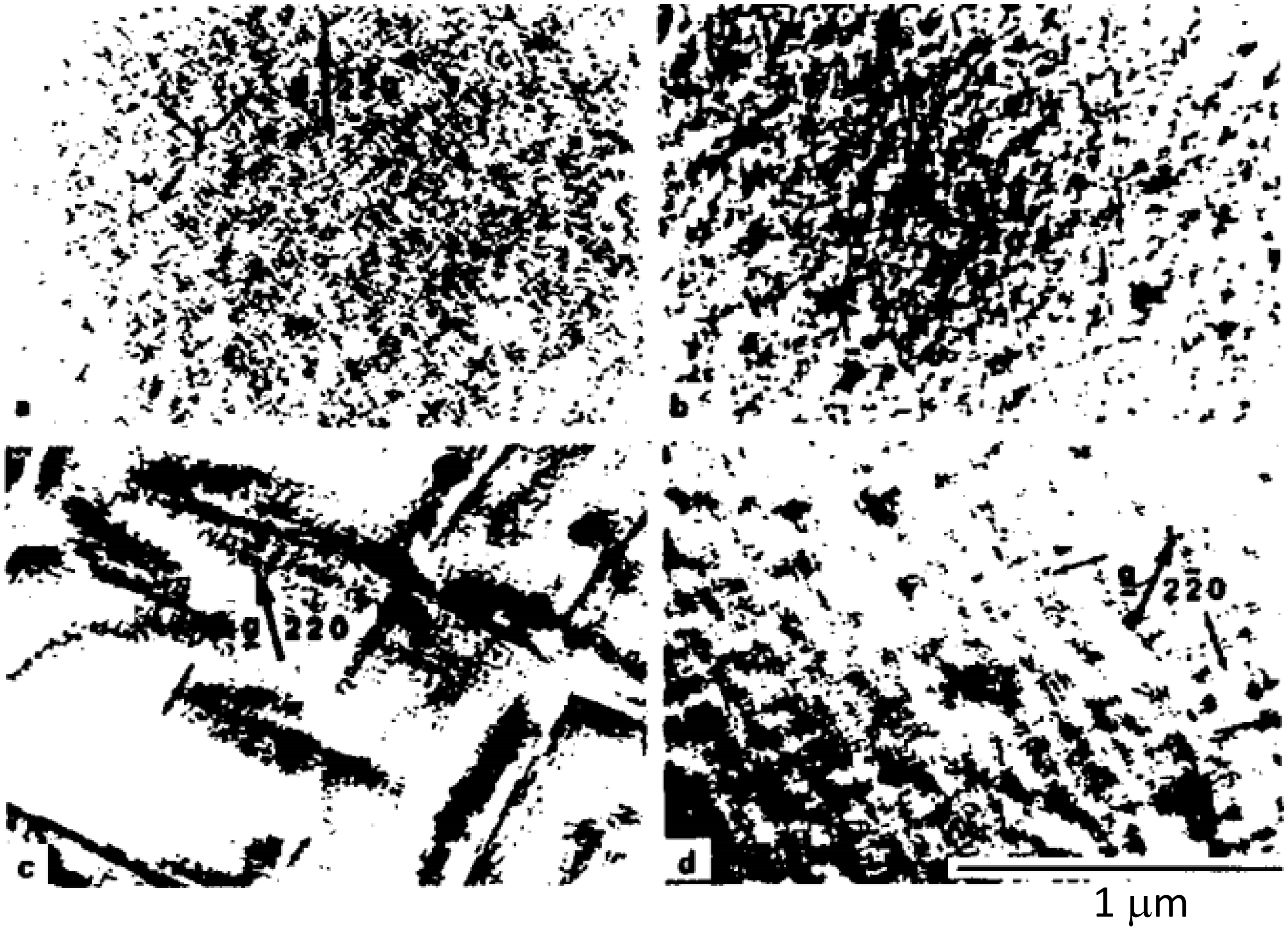
Phase separation in InGaAsP
(spinodal decomposition)



S. Mahajan, M.A. Shahid, D.E. Laughlin, Inst. Phys. Conf. Ser nr 100 3 (1989)