Alloy Semiconductors

Lattice constant and Vegard's law

- Consider two semiconductors A and B and the semiconductor alloy A_xB_{1-x}.
- x is the *alloy composition* or *alloy mole fraction*.
- Assume that A has a lattice constant a^A.
- Assume that B has a lattice constant a^B.
- The lattice constant of the alloy is given by:

$$a^{AB}(x) = x\, a^A + (1-x)\, a^B$$

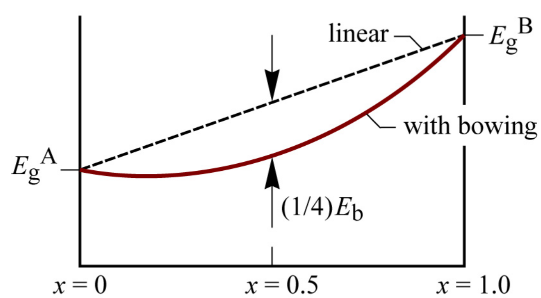
- This equation is called Vegard's law.
- Give an intuitive explanation as to why Vegard's law is valid.

Energy gap

- Consider two semiconductors A and B and the semiconductor alloy A_xB_{1-x}.
- Assume that A has the fundamental energy gap $E_g{}^A$.
- Assume that B has the fundamental energy gap $E_g{}^B$.
- The energy gap of the alloy is given by:

$$E_g(x) = x\, E_g^A + (1-x)\, E_g^B - x(1-x)\, E_b$$

where E_b is called the *bowing parameter* or *bowing energy*.



- What is the alloy mole fraction at which the deviation from the linear dependence is greatest? ($x = 0.5$)
- What is the type of dependence of the bowing? (parabolic dependence)
- What is the magnitude of the greatest deviation from the linear dependence? ($E_b / 4$)

Examples

- $Al_xGa_{1-x}N$ $E_g{}^{GaN} = 3.42$eV $E_g{}^{AlN} = 6.28$eV $E_b = 1.0$ eV
  Reference: *J. Appl. Phys*. **92**, 4837 (2002)
- $Ga_{1-x}In_xN$ $E_g{}^{GaN} = 3.42$eV $E_g{}^{InN} = 0.77$eV $E_b = 2.4$ eV
  Reference: *Solid State Communications* **115**, 575 (2000)
- $Al_{1-x}In_xN$ $E_g{}^{AlN} = 6.28$ eV $E_g{}^{InN} = 0.77$eV $E_b = 3.0$ eV
  Reference: *Solid State Communications*. **127**, 411 (2003)