

**Fabrication Engineering at the Micro and Nanoscale**  
**S. A. Campbell**  
**Solutions Manual Version 1.1b – Third Edition**

2.1) The nearest neighbor Ga atoms are at  
 $(-\alpha/4, \alpha/4, -\alpha/4)$ ,  $(-\alpha/4, -\alpha/4, \alpha/4)$ ,  $(\alpha/4, -\alpha/4, -\alpha/4)$ , and  $(\alpha/4, \alpha/4, \alpha/4)$ .

The distance  $3^{1/2} \alpha/4 = 0.254$  nm.

The ionic lengths are given as  $r_{\text{Ga}}^{-1} \sim 0.081$  nm and  $r_{\text{As}}^{-1} \sim 0.22$  nm. Then the sum of the ionic distances is slightly larger than the  $\alpha$  spacing in the crystal.

2.2) For the Ga atom at  $(\alpha/4, \alpha/4, \alpha/4)$ , the four nearest neighbors are at:  
 $(0, 0, 0)$ ,  $(\alpha/2, \alpha/2, 0)$ ,  $(\alpha/2, 0, \alpha/2)$  and  $(0, \alpha/2, \alpha/2)$ .  
 They are the As atoms on the faces of the unit cell.

2.3a) Referring to the phase diagram for GeSi, at 1100 °C, the equilibrium concentration in the melt is given as 15%.  
 b) The entire charge melts at 1190 °C.  
 c) If the material is in equilibrium, about 50% of the solid is silicon.

2.4) According to the phase diagram for GaAs, and excess Ga will tend to precipitate out as a liquid (pure Ga) if the temperature is above 29.8 °C. Since typical growth temperatures are much higher than this, droplets will form on the surface. When the material is then lowered to room temperature, these droplets should be slowly absorbed back into the stoichiometric GaAs where they solidify.

2.5) Solid solubility is an equilibrium value. It is possible, and in fact is often desirable, to incorporate an impurity concentration well above the solid solubility. Such a mixture will tend to precipitate over time, but at room temperature the time scales involved may be so long as to preclude any detectable amount of precipitation.

2.6 According to Equation 2.1,

$$N_v^+ = 5 * 10^{22} \text{ cm}^{-3} e^{-2.6eV/kT} = 2 * 10^{10} \text{ cm}^{-3}$$

Then

$$\frac{2.6eV}{kT} = \ln \frac{5 * 10^{22}}{2 * 10^{10}} = 28.5$$

Solving

$$T = \frac{2.6eV}{28.5 * 8.62 * 10^{-3} \text{ eV/K}} = 1058 \text{ K} = 785^\circ \text{C}$$

One can use this temperature to solve the problem as

$$N_v^+ = 2 * 10^{10} \text{ cm}^{-3} \frac{P}{n_i} e^{(E_v - E_i) / kT}$$

From Fig. 3.4,  $n_i = 2 * 10^{18} \text{ cm}^{-3}$ . Since  $N_{\text{Boron}} \ll n_i$ ,  $p = n_i$ . Then

# Microelectronic Fabrication Engineering Campbell

## Solution Manual

**Stephen A. Campbell**

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**Fabrication Engineering at the Micro and Nanoscale** Stephen A. Campbell, 2008-01-10 Designed for advanced undergraduate or first year graduate courses in semiconductor or microelectronic fabrication the third edition of Fabrication Engineering at the Micro and Nanoscale provides a thorough and accessible introduction to all fields of micro and nano fabrication

**The Science and Engineering of Microelectronic Fabrication** Stephen A. Campbell, Professor in the Department of Electrical and Computer Engineering Stephen A Campbell, 2001 The Science and Engineering of Microelectronic Fabrication provides a thorough introduction to the field of microelectronic processing Geared toward a wide audience it may be used for upper level undergraduate or first year graduate courses and as a handy reference for professionals The text covers all the basic unit processes used to fabricate integrated circuits including photolithography plasma and reactive ion etching ion implantation diffusion oxidation evaporation vapor phase epitaxial growth sputtering and chemical vapor deposition Advanced processing topics such as rapid thermal processing non optical lithography molecular beam epitaxy and metal organic chemical vapor deposition are also presented The physics and chemistry of each process is introduced along with descriptions of the equipment used for the manufacturing of integrated circuits The text also discusses the integration of these processes into common technologies such as CMOS double poly bipolar and GaAs MESFETs Complexity performance tradeoffs are evaluated along with a description of the current state of the art devices Each chapter includes sample problems with solutions The text makes use of the process simulation package SUPREM to demonstrate impurity profiles of practical interest The new edition includes complete chapter coverage of MEMS including Fundamentals of Mechanics Stress in Thin Films Mechanical to Electrical Transduction Mechanics of Common MEMS Devices Bulk Micromachining Etching Techniques Bulk Micromachining Process Flow Surface Micromachining Basics Surface Micromachining Process Flow MEMS Actuators High Aspect Ratio Microsystems Technology HARMST Fabrication Engineer Stephen Campbell, 2012-11-29 In the education area Professor Campbell leads the University of Minnesota's participation in Nano Link an NSF sponsored regional center for nanotechnology education at the AAS level He has designed and implemented a one semester capstone experience Microelectronic Fabrication and created the text book as a result Designed for advanced undergraduate or first year graduate courses in semiconductor or microelectronic fabrication this fourth edition of Fabrication Engineering at the Micro and Nanoscale provides a thorough and accessible introduction to all fields of micro and nano fabrication The text covers the entire basic unit processes used to fabricate integrated circuits and other devices THOMAS REGISTER 2005, 2005 **Computer Books and Serials in Print**, 1985 **Thomas Register of American Manufacturers**, 2003 Vols for 1970-71 includes manufacturers catalogs **Indexes to ... Publications** American Society of Mechanical Engineers, 1978 **Society Records** American Society of Mechanical Engineers, 1978

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