

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 $(-a/4, a/4, -a/4)$, $(-a/4, -a/4, a/4)$, $(a/4, -a/4, -a/4)$, and $(a/4, a/4, a/4)$.

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

The ionic lengths are given as $r_{\text{Ga}}^{+1} \sim 0.081 \text{ nm}$ and $r_{\text{As}}^{-3} \sim 0.22 \text{ nm}$. Then the sum of the ionic distances is slightly larger than the a spacing in the crystal.

2.2) For the Ga atom at $(a/4, a/4, a/4)$, the four nearest neighbors are at: $(0, 0, 0)$, $(a/2, a/2, 0)$, $(a/2, 0, a/2)$ and $(0, a/2, a/2)$. 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,

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

Then

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

Solving

$$T = \frac{2.6 \text{ eV}}{28.5 * 8.62 * 10^{-5} \text{ eV} / K} = 1058 K = 785^\circ\text{C}$$

One can use this temperature to solve the problem as

$$N_V^+ = 2 * 10^{10} \text{ cm}^{-3} \frac{p}{n_i} e^{(E_F - E_i) / kT}$$

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

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Stephen A. Campbell



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MEMS and NEMS Sergey Edward Lyshevski, 2018-10-03 The development of micro and nano mechanical systems MEMS and NEMS foreshadows momentous changes not only in the technological world but in virtually every aspect of human life The future of the field is bright with opportunities but also riddled with challenges ranging from further theoretical development through advances in fabrication technologies to developing high performance nano and microscale systems devices and structures including transducers switches logic gates actuators and sensors MEMS and NEMS Systems Devices and Structures is designed to help you meet those challenges and solve fundamental experimental and applied problems Written from a multi disciplinary perspective this book forms the basis for the synthesis modeling analysis simulation control prototyping and fabrication of MEMS and NEMS The author brings together the various paradigms methods and technologies associated with MEMS and NEMS to show how to synthesize analyze design and fabricate them Focusing on the basics he illustrates the development of NEMS and MEMS architectures physical representations structural synthesis and optimization The applications of MEMS and NEMS in areas such as biotechnology medicine avionics transportation and defense are virtually limitless This book helps prepare you to take advantage of their inherent opportunities and effectively solve problems related to their configurations systems integration and control 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 **Books in Print Supplement** , 1979 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

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