

# Fabrication Engineering at the Micro- and Nanoscale

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## Chapter 3

p. 48, Example 3.1, the notation  $D_-$  is used rather than  $D^-$  as used in equation 3.7.

p. 48, Example 3.1, the notation  $D_i$  is used rather than  $D^0$  as used in equation 3.7. Note that  $D_i$  is also used in equations (3.12) and (3.24) to mean the same thing as  $D^0$ .

p. 48, Example 3.1. The intrinsic carrier concentration at 1000 C is  $10^{19} \text{ cm}^{-3}$ . In the second part of the problem, this makes  $n=1.6 \times 10^{19}$ , and  $D=3.5 \times 10^{19} \text{ cm}^2/\text{sec}$ .

p. 48, Table 3.2, the notation of  $D_o^-$  is used in this table rather than  $D^{2-}$  as used in equation 3.7.

p. 48, Table 3.2, the notation of  $D_o$  is used in this table rather than  $D_o^0$  as used in equation 3.11.

p. 55, first sentence, the term  $D_i^-$  should be after the word “and”, not before. Also, this notation is inconsistent with equation (3.7) and should be  $D^{2-}$ . Also, this notation is not consistent with equation (3.24).

## Chapter 4

p. 76-78, the diffusivity of oxygen in the gas phase is  $D_{O_2}$  in equations (4.2) and (4.5), but the notation switches to  $D$  in equations (4.9), (4.10), and (4.12). Further, these terms are not explicitly defined in the text.

p. 76 – 77, equation (4.3) uses  $P_g$  for the partial pressure of oxygen in the furnace, but equation (4.8) uses a lower case “p”, as does the sentence just after equation (4.8).

p. 79, Table 4.1 and Figures 4.2 and 4.3 are based on (111) wafers, after the original Deal-Grove paper. The text incorrectly identifies them as for (100) wafers.

p. 84, equation (4.17), there is a minus sign missing from the argument of the exponential. The last bit of the equation should read  $[1 - e^{-\frac{B(t+\tau)}{AL^2}}]$

## Chapter 5

p. 115, middle of page, there is a missing exponent from “( $\ll 10^{-5}$  torr)”. The missing exponent is 5.

## Chapter 6

p. 149, the sentence before equation (6.5), “Differentiating Equation (6.1)” should read “Differentiating Equation (6.3)”.

p. 151, line 17, note that the emissivity of silicon is about 0.7 only for  $T > 600$  C.

p. 151, line 19, the reference to equation (6.2) should be to equation (6.4).

## Chapter 7

p. 176, line 11, the “225-nm reticle” should read “225-mm reticle”.

p. 176, fourth line from bottom, a typical DRAM process involves about 25 masks, and CMOS processes involve at least 50 masks.

p. 178, line 27 (and elsewhere in the text), the phrase “areal image” is incorrect. The correct phrase is “aerial image”, meaning the image in air.

p. 180, figure 7.6, the mask plate is labeled as being “fused silicon”. It should be “fused silica”.

p. 181-182, equations (7.9) and (7.10) give electric fields. It is confusing that the symbols used are  $I_x$  and  $I_y$ . Instead they should be  $E_x$  and  $E_y$ . Likewise, the label in figure 7.8.

p. 182, figure 7.8, both electric field and intensity are being plotted in this graph. The y-axis label should read “Normalized Intensity or Amplitude”.

p. 182, figure 7.8, the figure caption says “image” when it should say “diffraction pattern”.

p. 195, second line, typical values of  $k_1$  go down to 0.3, not 0.4.

p. 195, equation (7.19), the depth of focus should use the symbol DOF (instead of  $\sigma$ ) to be consistent with equation (7.23).

p. 195, line 23, the sentence “Virtually all modern projection printers use diffractive rather than reflecting optics” should read “Virtually all modern projection printers use refractive rather than reflecting optics”.

p. 196, equation (7.21), the symbol  $\Gamma$  is not defined. It is the pitch, and the symbol should be  $P$  to be consistent with equation (7.24).

p. 198, equation (7.24), the angle is not equal to  $\lambda/nP$ , the sine of the angle is equal to this quantity.

p. 201, end of first paragraph, the phrase “phase contrast mask” should read “phase shifting mask”.

p. 206, line just above figure 7.34, the global alignment is not done manually. It is an automatic process.

## Chapter 8

p. 213, 6<sup>th</sup> line from bottom, “monoclinic cyclic ring” should read “aromatic cyclic ring”. Huckel’s rule applies to planar molecules, an often monoclinic rings are not planar.

p. 215, section 8.3. The acronym “DQN” should read “DNQ”, which stands for diazonaphthoquinone.

p. 216, figure 8.5. This figure shows a DNQ not DQ.

p. 218, just after equation (8.1), the contrast is the absolute value of the slope of the line, since we quote a positive value for the contrast for both positive and negative resists.

p. 221, third line from bottom. The maximum useable spin speed depends on the wafer size. For 300 mm wafers, the spin speeds are in the range of 1000 – 2000 rpm.

p. 224, line 7. HMDS should be called an adhesion promoter, not a surfactant.

p. 225, second line from bottom. The sentence “If  $\alpha$  is too large...” should read “If  $\alpha$  is too small...”.

p. 226, line 20. The sentence “The actinic absorbance is defined...” should read “The bleachable absorbance is defined...”. Actinic absorbance is the absorbance that leads to a chemical reaction. It is sometimes equal to the bleachable absorbance, but often not.

p. 232, second paragraph, the reference to figure 8.16 should be a reference to figure 8.17.

## Chapter 9

p. 238, line 6, the phrase “phase contrast mask” should read “phase shifting mask”. Also, the “or other” before optical proximity correction is incorrect. A phase shifting mask is not a type of optical proximity correction.

p. 239, second paragraph of section 9.1, x-ray sources emit photons with energy between 1 keV and 10 keV, so that the wavelengths are between about 0.1 nm and 1 nm.

p. 239, figure 9.1, the labels  $\gamma_1$  and  $\gamma_2$  should instead by  $\lambda_1$  and  $\lambda_2$ .

p. 240, figure 9.2, the y-axis should have the label “Absorption Coefficient ( $\text{cm}^{-1}$ )”.

p. 240, equation (9.2). The following terms are not defined:  $\rho$  is the mass density, and  $m$  equals the molecular weight divided by Avogadro’s number.

p. 245, line 12, the phrase “100 m to 1 mm” should read “100  $\mu\text{m}$  to 1 mm”.

p. 251, line 9, Commercial EUV tools began shipping in 2013 (the ASML NXE:3300), and they cost about \$100,000,000 each.

p. 256, final paragraph before section 9.8, the maximum throughput of the alpha demo EUV tools was 4 hours per wafer, not four wafers per hour. The maximum throughput of the beta tools (the NXE:3100) was 6 wafers per hour, not 60.

## **Chapter 10**

p. 272, Equation 10.3 is incorrect. Remove the constant pi from the denominator.

## **Chapter 11**

p. 303, fourth line of section 11.2, the phrase “depth of field” should read “depth of focus”.

p. 309, line 30, the phrase “Si of SiO<sub>2</sub>” should read “Si to SiO<sub>2</sub>”.

## **Chapter 12**

p. 342, Example 12.1. In the equations that follow the line that begins “At 27° C, ...” there are two mistakes. The density of Si (2.33 g/cm<sup>3</sup>) was used instead of the density for H<sub>2</sub>O (1.0 g/cm<sup>3</sup>). Also, the term in the square root provides an answer of 930 m/sec, not 53.7. The resultant time is 258 msec.

## **Chapter 13**

p. 378, Equation 13.16 has an error. The  $k_{r1}$  term should be multiplied by  $C_{SiH_2}C_{H_2}$  not  $C_{SiH_4}C_{H_2}$ .

## **Chapter 16**

p. 501, figure 16.2, the voltages  $V_g$  and  $V_d$  should instead be  $V_{gs}$  and  $V_{ds}$ , respectively, to match the nomenclature used in the text.

p. 511, figure 16.14, the label “AL based metallurgy” should read “Al-based metallization”.