

## Errata - Fundamental Principles of Optical Lithography by Chris A. Mack

### *Errors not yet corrected:*

1. p251, the sentence after equation (6.98) should be changed from “The rest of the *CovPSF* simply gives the ratio  $dV/2\sigma_D \dots$ ” to “The rest of the *CovPSF* simply gives the ratio  $dV/\sigma_D \dots$ ”.
2. p490, glossary entry for Zernike Polynomial, the name “Fritz Zernike” should be correctly spelled as “Frits Zernike”.

### *Errors corrected in the Second Printing:*

1. p48, bottom of first paragraph, the reference “see section 2.1.3” should read “see section 2.1.4”.
2. p238, last sentence of the first paragraph should be deleted: “In general, the Poisson distribution is a good approximation to the binomial distribution whenever  $TL > 1$  (that is, you expect to see more than one photon in the allotted time).”
3. p239, first paragraph of section 6.4.2, the last sentence “And, for any reasonably large volume ( $CV > 1$ ), this binomial distribution will also be well approximated by a Poisson distribution.” should be changed to “And, as before, this binomial distribution will also become a Poisson distribution by letting  $dV$  go to zero.”
4. p244, the sentence preceding equation (6.62) should be changed from “After exposure, the number of photogenerated acid molecules  $Y$  will be” to “After exposure, the number of remaining (unexposed) PAG molecules  $Y$  will be”.
5. p245. the sentence preceding equation (6.66) should be changed from “At this point it is useful to relate the number of acid molecules per unit volume  $Y$  to the...” to “At this point it is useful to relate the number of remaining PAG molecules per unit volume  $Y$  to the...”
6. p246, 2<sup>nd</sup> paragraph, the sentence “Ignoring the photon shot noise, the probability distribution for the number of acids in a given volume is approximately Poisson” should be changed to “Ignoring the photon shot noise, the probability distribution for the number of acids in a given volume is Poisson” (that is, the word “approximately” should be deleted).
7. p246, the first part of equation (6.72) is incorrect. It should be:

$$\sigma_{h^*} = \sqrt{\frac{\langle h^* \rangle}{\langle n_{0-PAG} \rangle}}$$

8. p249, equation (6.90) should read

$$CovPSF = \frac{1}{dV t_{PEB}^2} \int_0^{t_{PEB}} \int_0^{t_{PEB}} E(y(t)y(t')) dt dt'$$

9. p249, equation (6.93) should read

$$P(y(t')=1 | y(t)=1) = \lim_{r' \rightarrow 0} \frac{e^{-r'^2/2\sigma^2}}{\sqrt{2\pi}\sigma} dV, \quad \sigma^2 = 2D|t-t'|$$

10. p250, equation (6.94) should read

$$CovPSF = \frac{dV}{4\pi D t_{PEB}^2} \int_0^{t_{PEB}} \frac{e^{-r^2/4Dt}}{\sqrt{t}} dt \int_0^{t_{PEB}} \frac{e^{-r'^2/4D|t-t'|}}{\sqrt{|t-t'|}} dt'$$

(note that the only change is that the second instance of  $r$  is replaced by  $r'$ .)

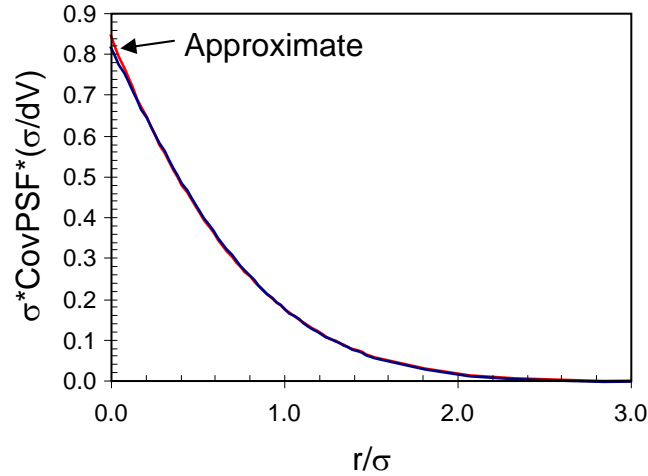
11. p250, equation (6.95) should be changed to

$$\lim_{r' \rightarrow 0} \frac{1}{\sqrt{4\pi D} t_{PEB}} \int_0^{t_{PEB}} \frac{e^{-r'^2/4D|t-t'|}}{\sqrt{|t-t'|}} dt' = \frac{t_{PEB}-t}{t_{PEB}} RDPSF(0, t_{PEB}-t) + \frac{t}{t_{PEB}} RDPSF(0, t)$$

12. p250, the sentence before equation (6.97) should be changed from “A numerical integration shows that the 1D *CovPSF* is very similar to the *RDPSF*, but with the diffusion length replaced by  $\sigma/2$ .” to “A numerical integration shows that the 1D *CovPSF* is very similar to the 1D *RDPSF*.”. Additionally, equation (6.97) should be changed to

$$CovPSF(r) \approx 1.05 \frac{dV}{\sigma} RDPSF(r)$$

13. Figure 6.9 should be replaced by



14. p250, last paragraph, the second sentence should be changed from “The shape of the *CovPSF* is very similar to that of the *RDPSF*, but with an effective diffusion length that is less by a factor of 2.” to “The shape of the *CovPSF* is very similar to that of the *RDPSF*.”

15. p251, the bottom equation (6.98) should be changed to

$$\sigma_{h_{eff}} \approx \sqrt{\frac{dV}{\sigma_D}} \sigma_h$$

16. p251, the third sentence after equation (6.98) should be changed from “In other words,  $dV/2$  represents how close the acid must come to a blocked site before it can potentially participate in a deblocking reaction (called the capture range,  $a$ .)” to “In other words,  $dV/2$  represents how close the acid must come to a blocked site before it can potentially participate in a deblocking reaction (called the capture radius,  $a$ .)”

17. p251, equation (6.99) should be changed to

$$\sigma_{h_{eff}} \approx \left( \frac{2a}{\sigma_D} \right)^{\frac{p}{2}} \sigma_h$$

18. p253, equations (6.110) - (6.112) should all be changed by replacing “ $a$ ” with “ $2a$ ”:

$$\sigma_m^2 = \frac{\langle m \rangle}{\langle n_{0-blocked} \rangle} + \left( \frac{\langle m \rangle \ln \langle m \rangle}{\langle h \rangle} \right)^2 \left( \frac{\sigma_h}{\langle h \rangle} \right)^2 \left( \frac{2a}{\sigma_D} \right)^p \quad (6.110)$$

$$\sigma_m^2 = \frac{\langle m \rangle}{\langle n_{0-blocked} \rangle} + \left( \frac{\langle m \rangle \ln \langle m \rangle}{\langle h \rangle} \right)^2 \left( \frac{2a}{\sigma_D} \right)^p \left( \frac{\langle h \rangle}{\langle n_{0-PAG} \rangle} + \frac{\left[ (1 - \langle h \rangle) \ln(1 - \langle h \rangle) \right]^2}{\langle n \rangle} \right) \quad (6.111)$$

$$\left(\frac{\sigma_m}{\langle m \rangle}\right)^2 = \frac{1}{\langle n_{0\text{-blocked}} \rangle \langle m \rangle} + (K_{amp} t_{PEB})^2 \left(\frac{2a}{\sigma_D}\right)^p \left( \frac{\langle h \rangle}{\langle n_{0\text{-PAG}} \rangle} + \frac{[(1-\langle h \rangle)\ln(1-\langle h \rangle)]^2}{\langle n \rangle} \right) \quad (6.112)$$

19. p253, equation (6.114) should be changed to

$$\begin{aligned} \left(\frac{\sigma_m}{\langle m \rangle}\right)^2 &= \frac{1}{\langle n_{0\text{-blocked}} \rangle \langle m \rangle} + (2\pi\sigma_D^2 a \langle G_0 \rangle N_A)^2 \left(\frac{2a}{\sigma_D}\right)^3 \left(\frac{\langle h \rangle}{\langle n_{0\text{-PAG}} \rangle}\right) \\ &= \frac{1}{\langle n_{0\text{-blocked}} \rangle \langle m \rangle} + 32\pi^2 \left(\frac{\sigma_D a^5}{V^2}\right) \langle h \rangle \langle n_{0\text{-PAG}} \rangle \\ &= \frac{1}{V} \left[ \frac{1}{\langle M_0 \rangle N_A \langle m \rangle} + 32\pi^2 \sigma_D a^5 \langle h \rangle \langle G_0 \rangle N_A \right] \end{aligned}$$

20. p253, in the paragraph following equation (6.114), the text that reads “ $\sigma_D/9 = 5$ ” should read “ $\sigma_D/2a = 5$ ”.

21. p254, figure 6.10, the  $x$ -axis label should be changed from “ $\sigma_D/a$ ” to “ $\sigma_D/2a$ ”.

22. p305, second line of section 8.2.3, the word “methodology” should read “method”.

23. p357, line 4, the statement “ $k$  less than about 0.8” should read “ $k_1$  less than about 0.8”.

24. p404-406, equations (9.92) and (9.95) – (9.99) should all be changed by replacing “ $a$ ” with “ $2a$ ”:

$$\sigma_{m^*}^2 = \frac{\langle m^* \rangle}{\langle n_{0\text{-blocked}} \rangle} + (\langle m^* \rangle \ln \langle m^* \rangle)^2 \left(\frac{2a}{\sigma_D}\right)^p \left( \frac{1}{\langle n_{0\text{-PAG}} \rangle \langle h \rangle} + \frac{[(1-\langle h \rangle)\ln(1-\langle h \rangle)]^2}{\langle h \rangle^2 \langle n \rangle} \right) \quad (9.92)$$

$$\sigma_{m^*} = \sqrt{\frac{\langle m^* \rangle}{\langle n_{0\text{-blocked}} \rangle} + (\langle m^* \rangle \ln \langle m^* \rangle)^2 \left(\frac{2a}{\sigma_D}\right)^p \left( \frac{1}{\langle n_{0\text{-PAG}} \rangle \langle h \rangle} \right)} \quad (9.95)$$

$$LER \propto \frac{\sigma_D^2}{1 - e^{-\pi^2 \sigma_D^2 / 2L^2}} \sqrt{\frac{\langle m^* \rangle}{\langle n_{0\text{-blocked}} \rangle} + (\langle m^* \rangle \ln \langle m^* \rangle)^2 \left(\frac{2a}{\sigma_D}\right)^p \left( \frac{1}{\langle n_{0\text{-PAG}} \rangle \langle h \rangle} \right)} \quad (9.96)$$

$$LER \propto \frac{\sigma_D^2}{1 - e^{-\pi^2 \sigma_D^2 / 2L^2}} \sqrt{1 - (K_{amp} t_{PEB}) \langle m^* \rangle \ln \langle m^* \rangle \left(\frac{2a}{\sigma_D}\right)^p \frac{\langle n_{0\text{-block}} \rangle}{\langle n_{0\text{-PAG}} \rangle}} \quad (9.97)$$

$$LER \propto \left(1 + \frac{\pi^2 \sigma_D^2}{4L^2}\right) \sqrt{1 - (K_{amp} t_{PEB}) \langle m^* \rangle \ln \langle m^* \rangle \left(\frac{2a}{\sigma_D}\right)^p \frac{\langle n_{0\text{-block}} \rangle}{\langle n_{0\text{-PAG}} \rangle}} \quad (9.98)$$

$$LER \propto \frac{\sigma_D^2}{1 - e^{-\pi^2 \sigma_D^2 / 2L^2}} \sqrt{1 + 15 \left( \frac{2a}{\sigma_D} \right)^p} \quad (9.99)$$

25. p406, Figure 9.28, references in the figure and in the figure caption to  $a = 1, 2,$  and  $3$  nm should be changed to  $0.5, 1.0$  and  $1.5$  nm.

26. p406, first sentence of the last paragraph before the start of the Summary section, the sentence "... deprotection capture range  $a, 1, 2,$  and  $3$  nm" should be changed to "... deprotection capture range  $a, 0.5, 1.0,$  and  $1.5$  nm".

27. Chapter 10, homework problem 10.1, the last sentence should be changed from "Assume equal lines and spaces, ..." to "Assume a 193-nm wavelength, equal lines and spaces, ...".

28. Chapter 10, homework problem 10.11. Add to the end of the problem the question: "What is the result for the case of equal lines and spaces?"

Additionally, my brief bio on the back cover of the book mistakenly lists my affiliation as KLA-Tencor. I left KLA-Tencor in November, 2005 and now exist as an independent "Gentleman Scientist".