Litografia par estruturas reais

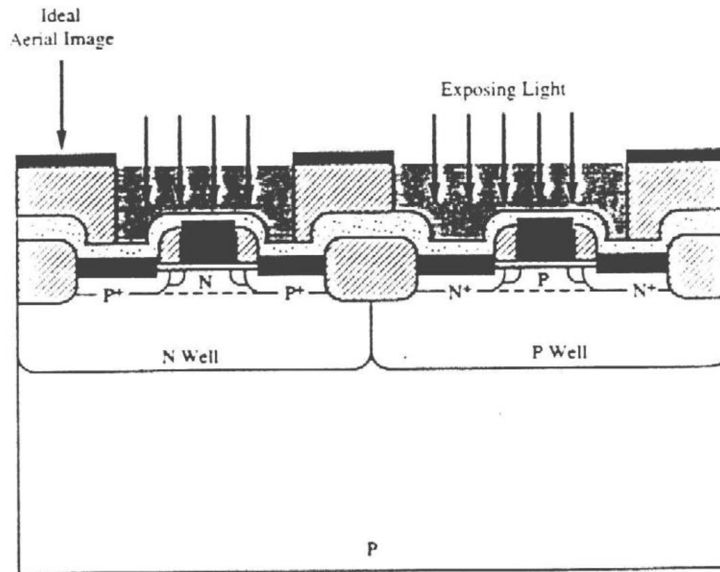


Figure 5–22 Exposure process associated with Figures 2–36 and 2–37 in the CMOS process in Chapter 2. The black bars in the aerial image represent areas on the mask that are opaque and hence ideally no photons strike the resist in these areas.

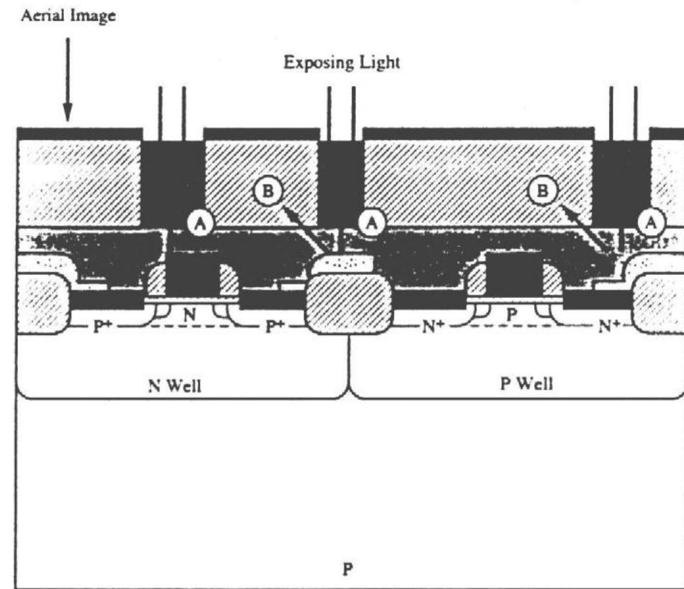


Figure 5–23 Photolithography exposure occurring between Figures 2–39 and 2–40 in the CMOS process described in Chapter 2. The A and B symbols indicate examples of standing wave patterns and sideways light scattering, respectively.

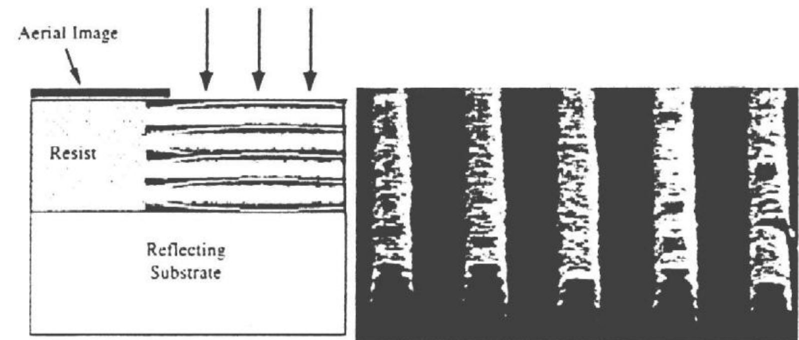


Figure 5–24 The light intensity pattern resulting from a standing wave is sketched on the left. A photoresist image that illustrates these effects after developing is shown on the right. Courtesy of A. Vladar and P. Rissman, Hewlett Packard.

Correção de máscaras (OPG- *óptical proximity correction*)

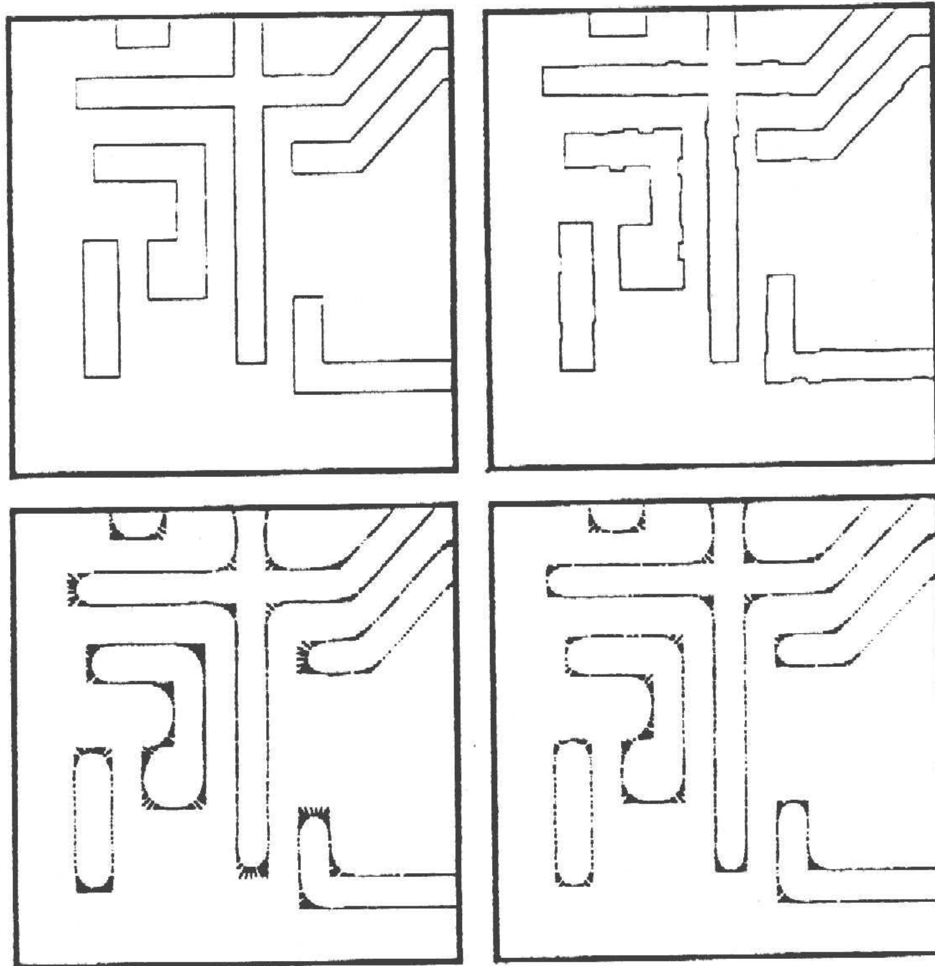


Figure 5–25 Mask patterns with (right) and without (left) OPC are shown on the top. The corresponding aerial images (calculated) are shown on the bottom. Note the improvement in the quality of the aerial image when OPC is used. The dark lines in the bottom patterns indicate the difference between the mask and aerial image in each case [5.13]. Reprinted with permission of SPIE.

Phase shifting technique : melhoria em contraste

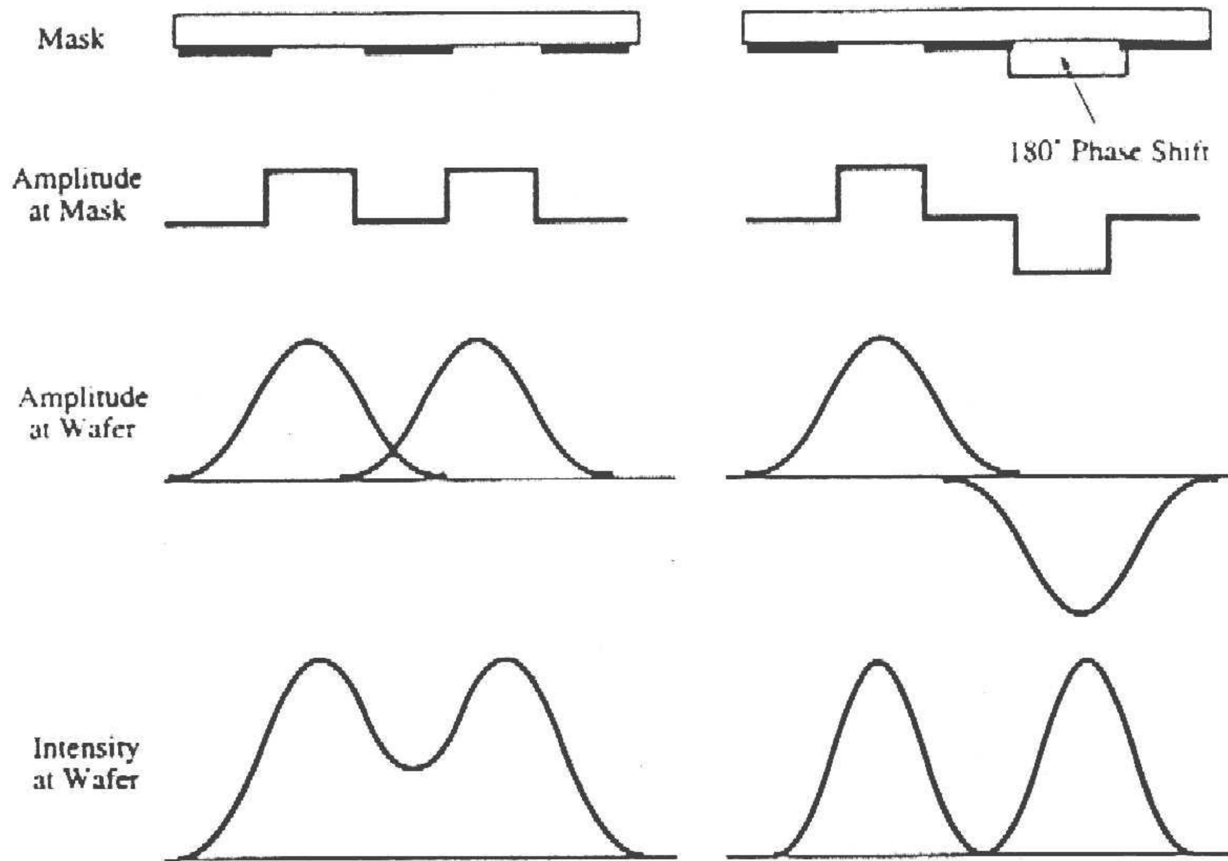


Figure 5–26 Example of the use of phase shifting techniques on masks to improve the resolution of the aerial image. (After Levenson et al. [5.32].)

Sistema de projeção de varredura (1:1),

com alta efficiência (*throughput*),

usado para lâminas grandes

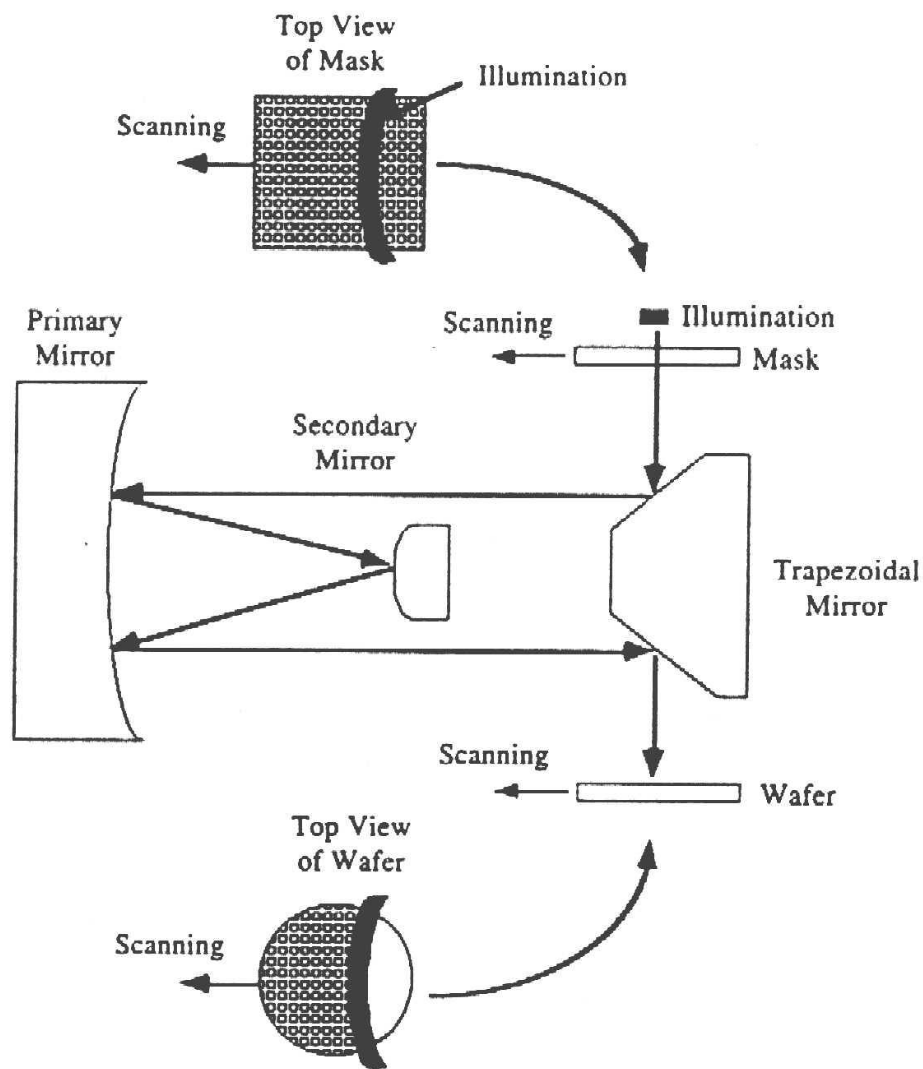


Figure 5–27 Conceptual diagram of a scanning projection printer.

Seqüência de gravação *step-and-repeat*

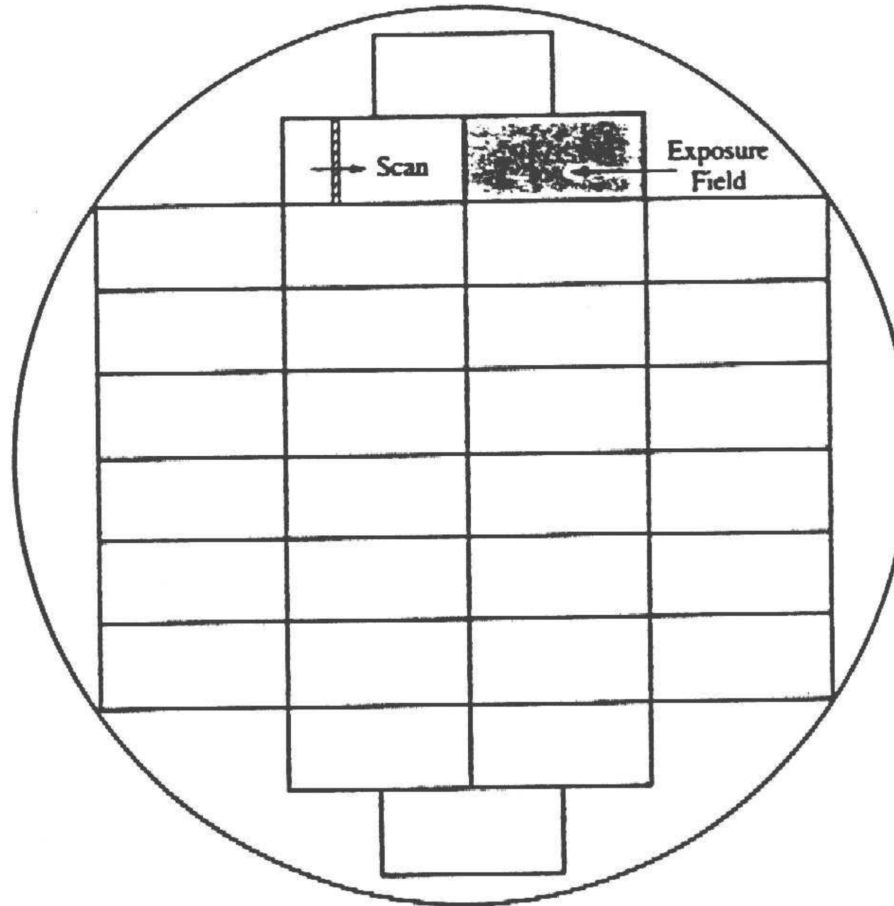


Figure 5–30 Step and scan system. Stepping accomplishes the major moves from one exposure field to another. Within each exposure field, the mask pattern is scanned across the field.

Espessura de resiste em função da velocidade de *spinner*

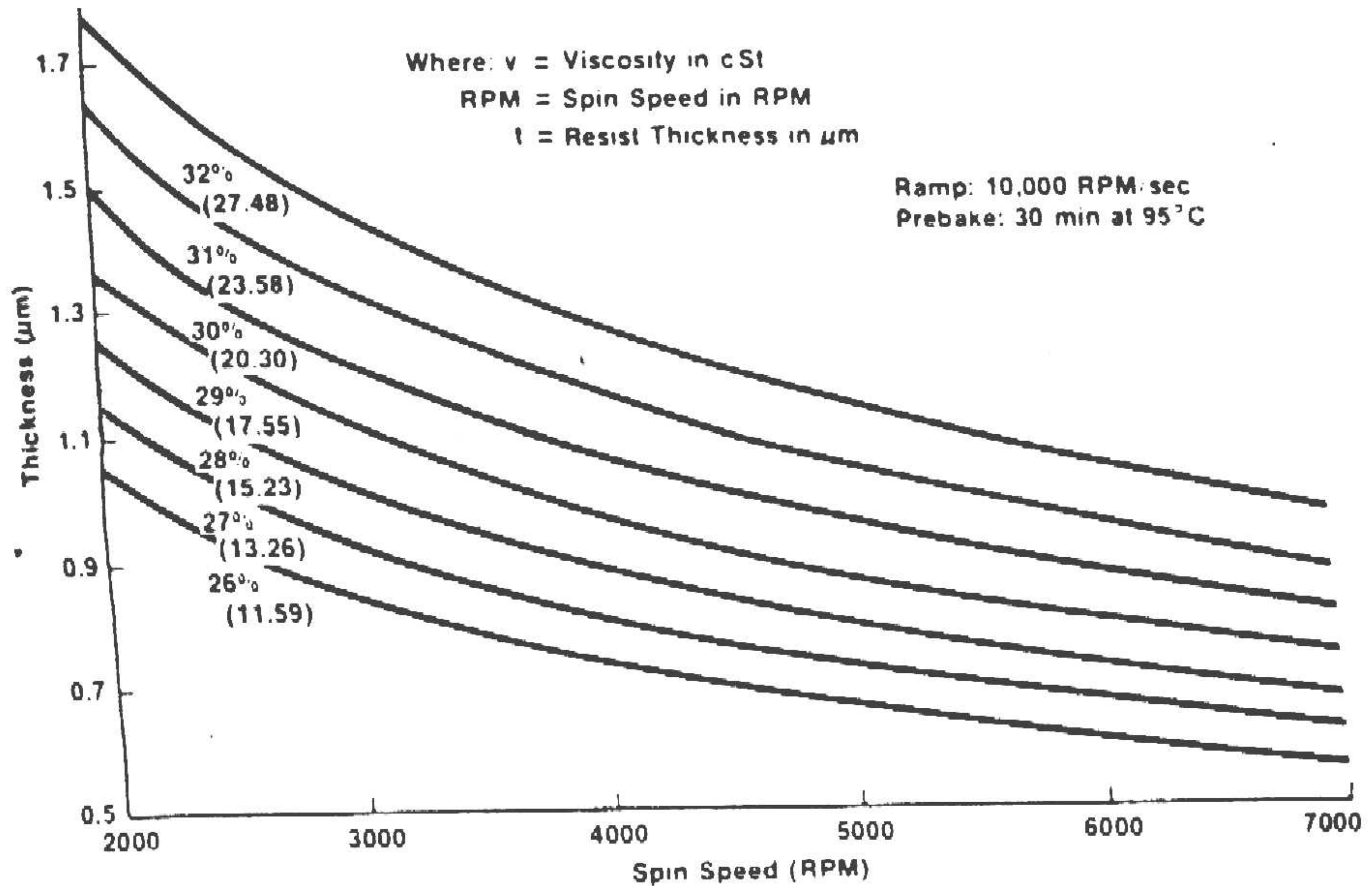


Fig. 17 Thickness vs spin speed of Kodak 820 resist. Courtesy of Eastman-Kodak Con

Dispositivos para recozimento (*baking*) de resiste

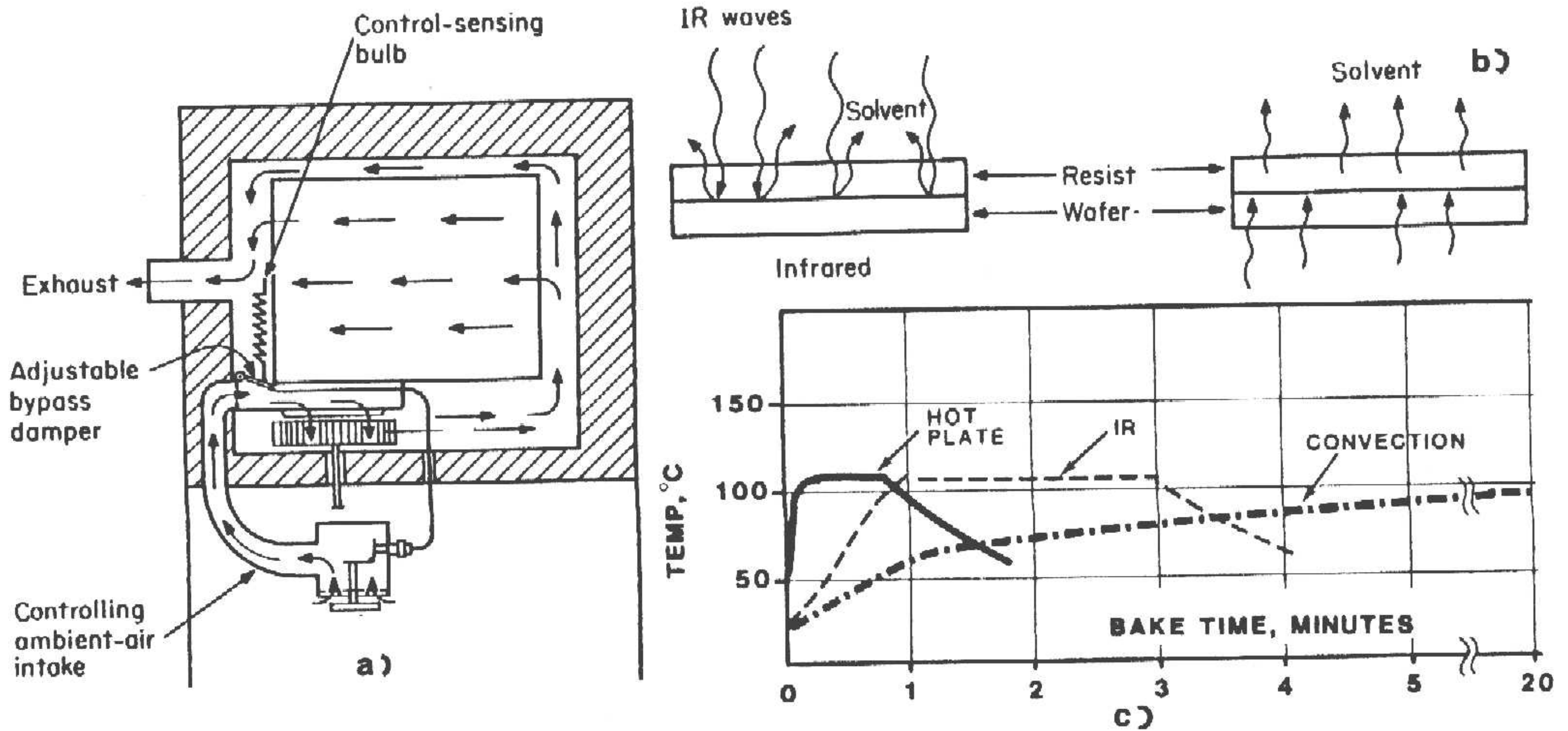


Fig. 20 (a) Convection oven cross section. Courtesy of Blue M, a Unit of General Signal. (b) Infrared and conduction solvent removal mechanisms. (c) Profiles for various bake methods[45]. Reprinted with permission of the Eaton Corporation.

Exposição: efeito do tempo

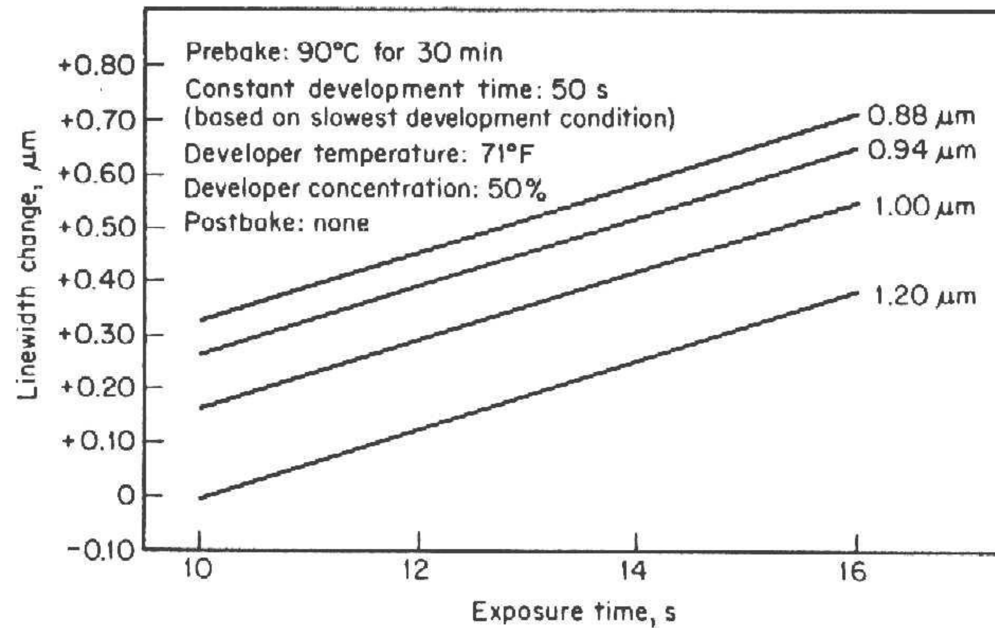
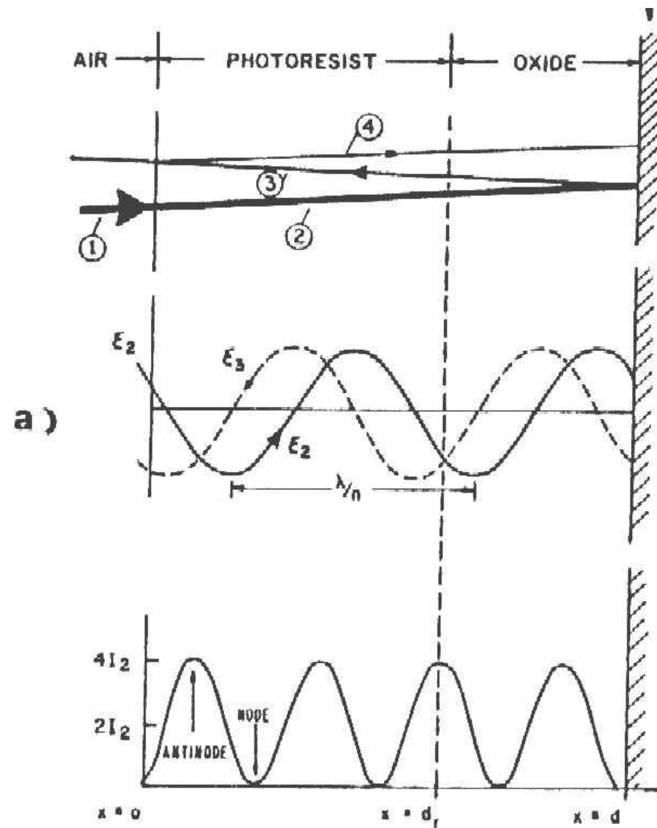
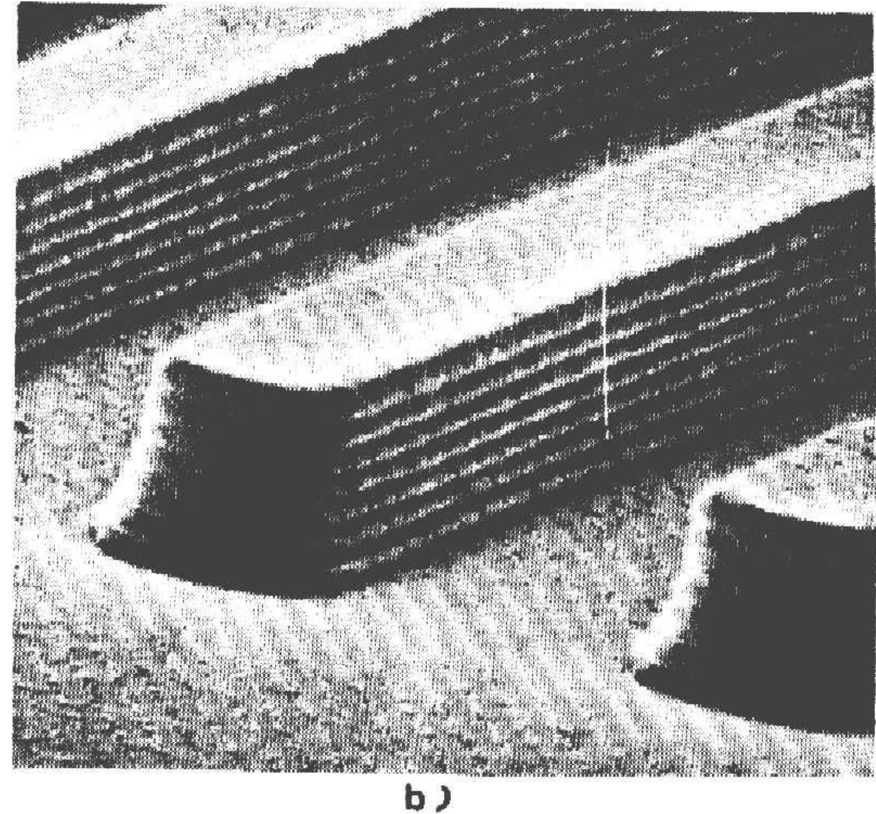


Fig. 21 Resist thickness and exposure-time relationship versus linewidth change[79]. Courtesy of Eastman-Kodak Company.

Interferência da luz dentro de resiste: ondas estacionárias





b)

Fig. 22 (a) Standing light waves in a resist film caused by interference between the incident and refelcted film[80]. (b) Photograph of standing wave effects in exposed resists.

Anti-reflection coating, exemplo de uso

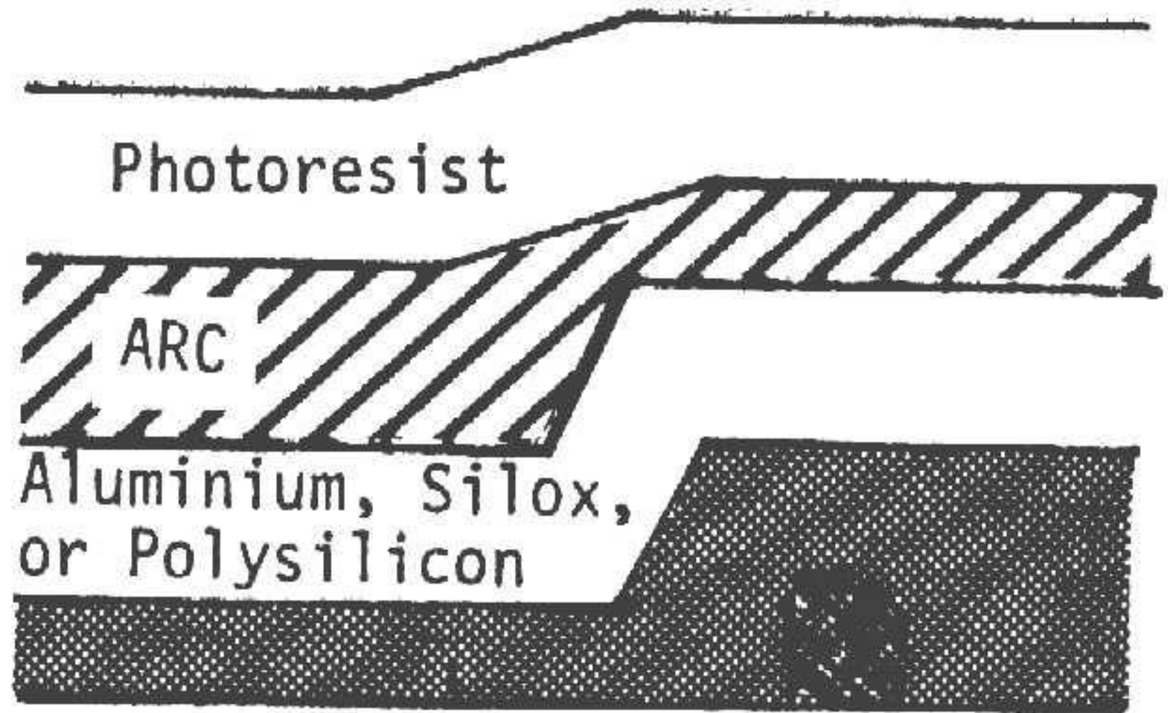


Fig. 25 Anti-reflection coating.

Revelação: efeito do tempo

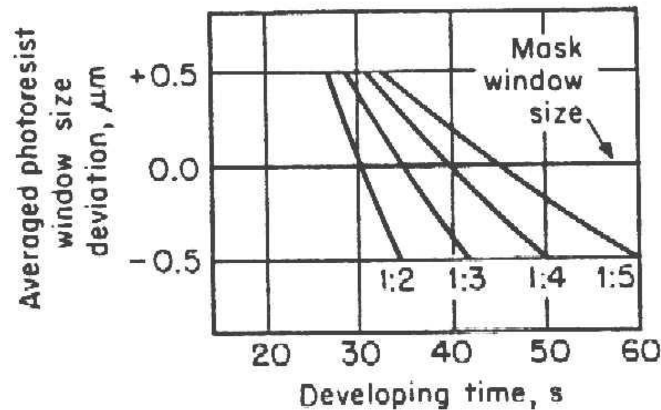


Fig. 28 Example of photoresist window-size deviation versus developing time. Courtesy of Shipley Company.

Litografia com feixe de elétrons

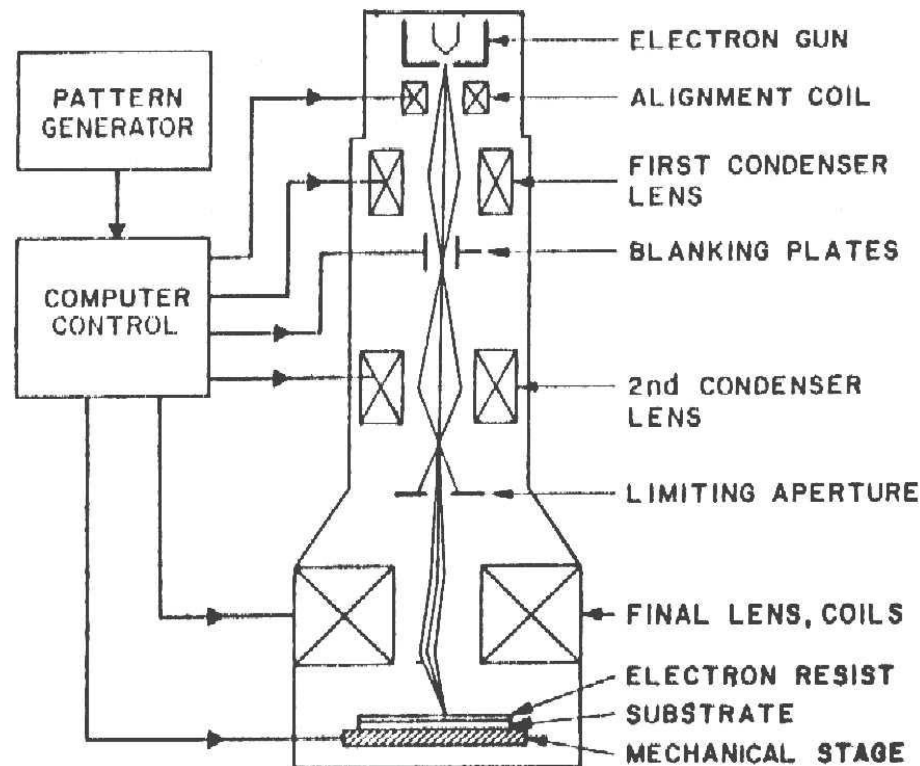


Fig. 1 Schematic of an electron beam machine. From Kern, *et al, Solid State Technol.*, **27**, 1984. p. 127. Reprinted with permission of Solid State Technology, published by Technical Publishing, a Company of Dun & Bradstreet.

Espalhamento de elétrons em resiste e substrato, efeito de proximidade

ELECTRON BEAM
DIRECTION OF SCAN
DESIRED LINE
RESIST
REAL RESIST IMAGE
SUBSTRATE

Fig. 7 Electron scattering effects in resist-coated substrate[8]. Reprinted with permission of Semiconductor International.

Efeitos de inter- e intra-proximidade

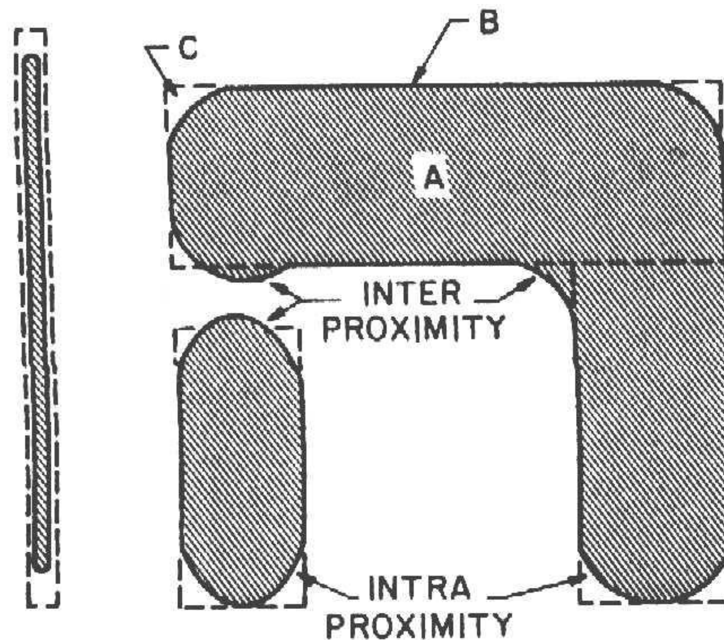


Fig. 8 *Inter* and *intra* proximity effects in e-beam exposure caused by electron scattering[8]. Reprinted with permission of Semiconductor International.