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Chapter 3 - Photolithography

The three pages that follow are a section from the photolithography chapter in "Process Technology for the 21st Century" originally published in 1999 by Semiconductor Consulting Services. Now offered by IC Knowledge under license, we offer individual chapters delivered electronically at a significant discount to the printed book cost.

The section that follows covers step and scan exposure systems and indicates the depth and type of coverage in the chapter. For a list of other available chapters please go to: http://www.icknowledge.com/our_products/pt21c.html. To order this or any other chapter please go to: http://www.icknowledge.com/Order/order.mv

3.7.1 Step and Scan

I-Line exposure introduced a new type of exposure system called step and scan. As seen previously, difficulties in producing large diameter optics with high numerical apertures have limited step and repeat field sizes to a maximum of 31mm in diameter. As die sizes have increased a point was reached where for certain die, only one die could fit in a round step and repeat system lens field. An innovation developed by the Perkin Elmer corporation called step and scan increased the available field size by scanning the lens field in a manner similar to the previously described projection lithography. Figure 3.19 illustrates the basic concept of lens scanning.

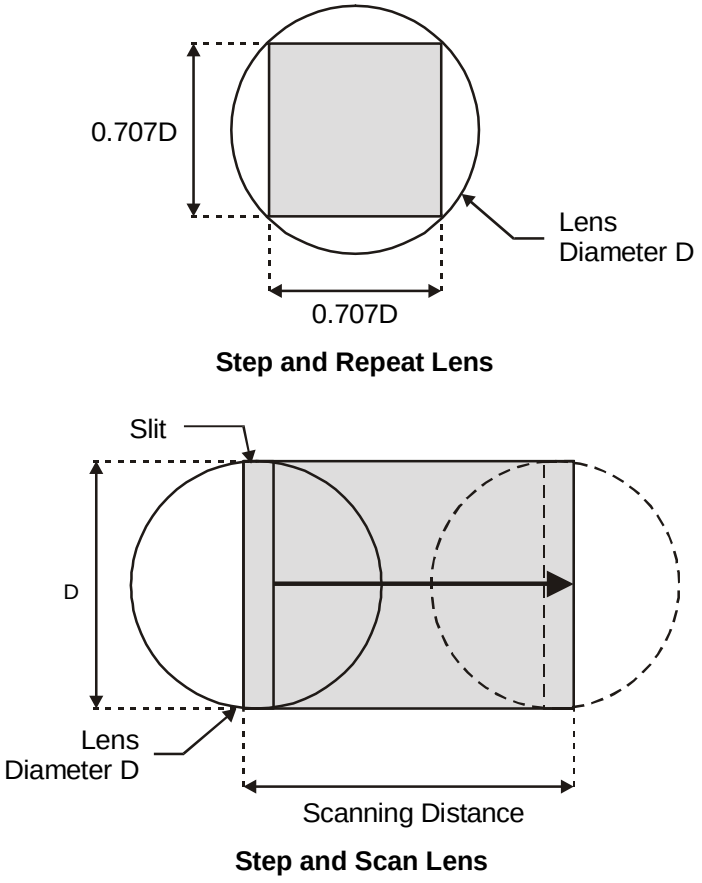

Figure 3.19 Step and Repeat Versus Step and Scan Field Size

In the top of figure 3.19 it is shown how a square die fits inside of a round step and repeat exposure tool lens (shaded area). In the bottom of figure 3.19 the same lens size is shown with a scanning slit in the center of the lens. The lens and slit is used to "scan" the mask image onto the wafer. By using a relatively narrow slit the slit length can be longer than a single side dimension for a square die and the second dimension of the field is limited only by the scan length and the reticle size. The shaded area in the bottom part of figure 3.19 shows the much larger rectangular area that a scanning approach can print because the scan length is only limited by the mechanical scanning. Note that the much larger rectangular area printed by a scanning approach is achieved with the same size lens as the conventional step and repeat system. Once a field has been scanned onto the wafer the exposure system steps to the next site and scans another field.

For a 6" reticle (150mm) with a useable area of 140mm, the maximum size of any square die dimension in a standard 5x reduction step and repeat exposure tool would be 140/5, or 28mm. To increase the maximum size die that a step and scan system can image onto a wafer, the reduction ratio for step and scan tools has been reduced to 4:1. With a 4:1 ratio a 6" reticle with a 140mm usable area can support a field size of 140/4, or 35mm.

There is an effort underway in the industry to migrate toward 9" reticles (230mm) that will have a usable area of 200mm. A 9" reticle with 200mm of usable area can support a field size of 200/4 = 50mm. The 35mm maximum field size supported by a 6" reticle (at 4:1) should be sufficient until the 100nm linewidth generation or smaller (as linewidths are getting smaller, transistor per die and die size are increasing).

Figure 3.20 illustrates a Silicon Valley Group Lithography (SVGL) type commercial step and scan system.

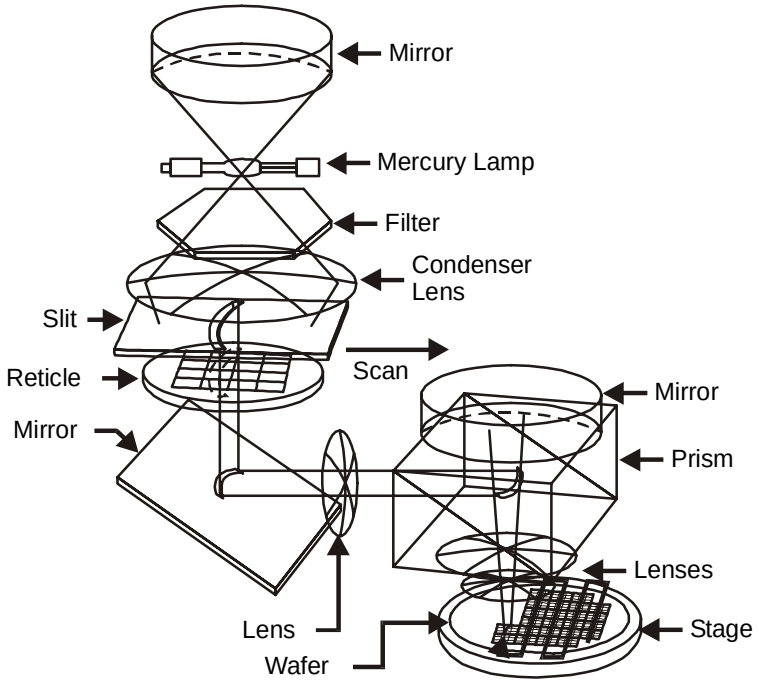

Figure 3.20 Commercial Step and Scan Exposure System

Notice how the optical system in figure 3.20 included reflective as well as refractive lens elements. The particular step and scan solution illustrated in figure 3.20 is based on the SVGL Micrascan architecture. The SVGL Micrascan is an obvious descendent of the late seventies Perkin Elmer Corporation projection printers with the use of scanning and reflective optics. The inclusion of reflective elements in the optics make the lens system less sensitive to exposure wavelength variations and are also reported to result in a much smaller lens system than all refractive optics. In fact SVGL reports that a catadioptric lens (refractive-reflective) weights 350 pounds versus 875 pounds for an all refractive lens system.

3.7.2 Anti Reflective Coatings

When a pattern is being exposed into a photoresist layer, the underlying substrate reflectivity can influence the exposure. As the underlying substrate reflectivity increases -