Algebra: Equipment Engineer

Zilog, Inc.

Job Description: Repair and maintenance of robotics in the photolithography (optics) department.

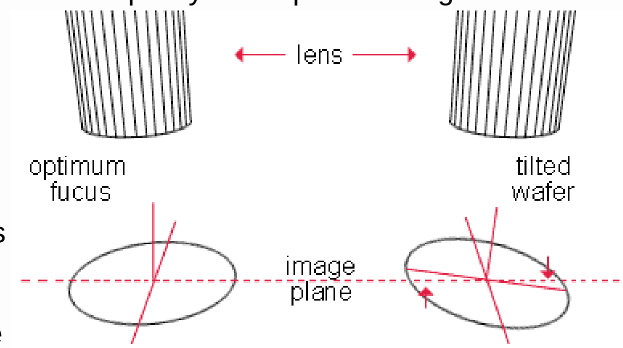
Problem:

In the last ten years, we have seen microchips become larger to accommodate a wide range of electronic functions. At the same time the physical geometries of the chips had to be reduced to improve the electrical characteristics and reduce the overall size. These advances in microchip technology occurred because of the capabilities of the photolithographic equipment.

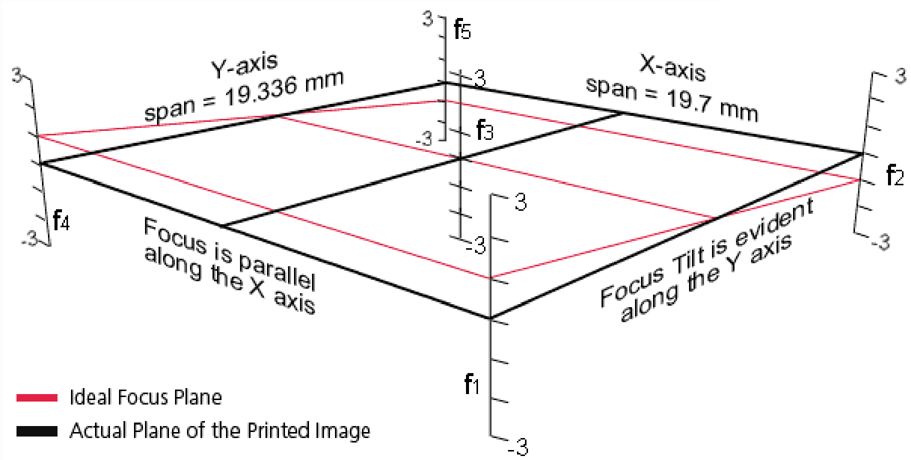
To increase the area of exposure, lenses were made with larger numerical apertures. As the apertures increase, the depth of focus decreases. Depth of focus is a distance measured from the optimum focus plane in which the quality of the printed image does not change.

Ten years ago, lenses had a depth of focus of 10 microns and today the normal depth of focus is 1 to 2 microns.

As we expose two images on the wafers, it is extremely important that the entire wafer be as close to the optimum focal plane as possible. If the wafer is tilted, a portion of the image may be outside the depth of focus. To insure this does not happen, we run a test called uneven focus.



Graphic representation of uneven focus along the y axis



To calculate the offsets necessary to correct for x and y tilt, substitute the best focus values in the following equations. Compare results to the specification of <25ppm (parts per million).

$$\text{X tilt} = \frac{\frac{f_1 + f_2}{2} - \frac{f_4 + f_5}{2}}{\text{x span}} \times 1{,}000 \text{ ppm}$$

$$\text{Y tilt} = \frac{\frac{f_1 + f_4}{2} - \frac{f_2 + f_5}{2}}{\text{y span}} \times 1{,}000 \text{ ppm}$$

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See problem for details.

Solution:

The following are the calculations required to determine the tilt correction:

$$\text{X tilt} = \frac{\frac{f_1 + f_2}{2} - \frac{f_4 + f_5}{2}}{\text{x span}} \times 1{,}000 \text{ ppm}$$

$$\text{X tilt} = \frac{\frac{-1 + 1}{2} - \frac{-1 + 1}{2}}{19.7} \times 1{,}000 \text{ ppm}$$

$$\text{X tilt} = \frac{\frac{0}{2} - \frac{0}{2}}{19.7} \times 1{,}000 \text{ ppm}$$

$$\text{X tilt} = \frac{0 - 0}{19.7} \times 1{,}000 \text{ ppm} = 0 \text{ ppm}$$ (no tilt along x-axis, as illustrated)

$$\text{Y tilt} = \frac{\frac{f_1 + f_4}{2} - \frac{f_2 + f_5}{2}}{\text{y span}} \times 1{,}000 \text{ ppm}$$

$$\text{Y tilt} = \frac{\frac{-1 - 1}{2} - \frac{1 + 1}{2}}{19.336} \times 1{,}000 \text{ ppm}$$

$$\text{Y tilt} = \frac{\frac{-2}{2} - \frac{2}{2}}{19.336} \times 1{,}000 \text{ ppm}$$

$$\text{Y tilt} = \frac{-1 -1}{19.336} \times 1{,}000 \text{ ppm}$$

$$\text{Y tilt} = \frac{-2}{19.336} \times 1{,}000 \text{ ppm}$$

$$\text{Y tilt} = -.103 \times 1{,}000 \text{ ppm} = -103 \text{ ppm}$$

This value exceeds the 25 ppm specification. Therefore, a software offset must be made.