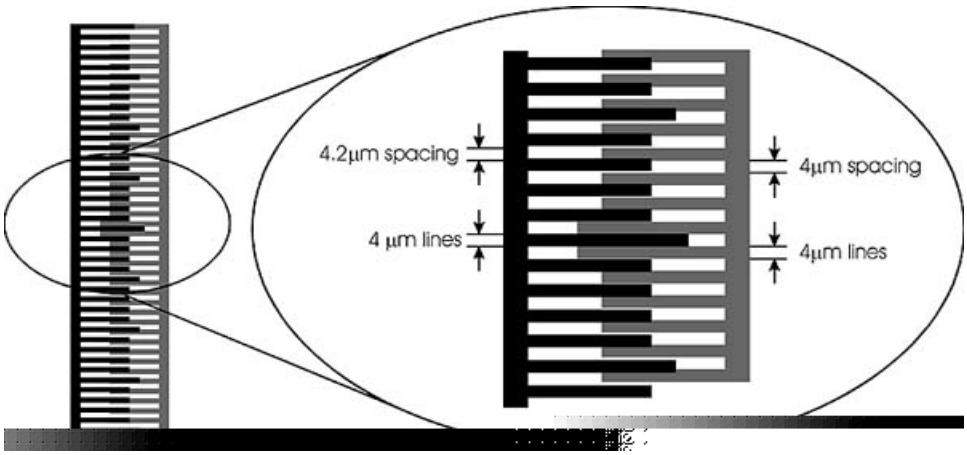
Using Vernier Scales

Vernier scales allow us to resolve alignment errors much more acurately than the minimum feature size for agiven process. To gain this fine resolution, they depend on accurately spaced lines. The picture on the left is a close resemblance to the verniers on your wafer. The picture on the right is a magnified version of the vernier. The black structure has lines which are 4 μm wide and spaces which are 4.2 mm wide. The grey structure has both lines and spaces which are 4 μm. wide.



If you were lucky and the mask alignment were perfect, vernier spacing like that of the picture above would be on your wafer. Most likely there is some misalignment. To measure this, find where one of the lines on the left vernier is exactly in the middle of two of the right lines. The misalignment is read as the number of lines from the long line on the left structure times the offset, 0.2 μm in this case. Therefore, the 0.2 μm offset in spacing gives us 0.2 μm of resolution.

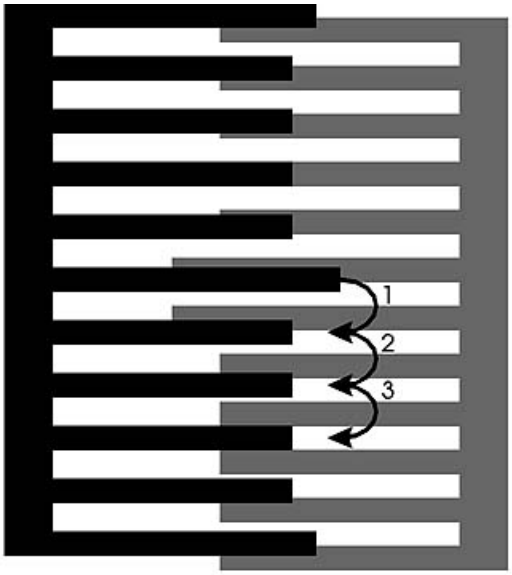
Now you must make sure you have the sign right. If you count lines going up, the structure on the right is shifted up. Likewise the left vernier is shifted down. Alternatively, if you look at the big picture, it should be obvious if the right structure is above or below the left structure. This makes a good sanity check.

If the vernier is drawn correctly, the ends wrap around. This helps when the misalignment is very large. If there is a large misalignment, greater than the line width, you will notice that the fingers which align are in the opposite direction of which you would expect. So, if the right vernier were shifted up by more than a line, but less than a line and a space, the fingers which match would be below the reference instead of above.

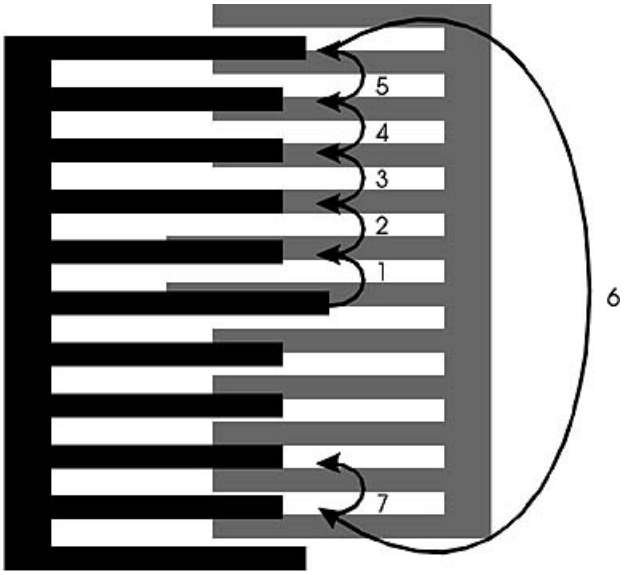
If the alignment is greater than the width of one line and one space, you will need to add the extra distance of the line and space, or multiple line and space pairs depending on the degree of misalignment

The drawings below are examples which show these three cases. Notice that the offset is larger for these verniers than what is shown above. For the examples, the lines and spaces are 0.1 inches wide. The offset is 0.02 inches.

The first example shows a misalignment of 0.06 inches. To read the vernier, first determine which black line is aligned in the middle of two grey lines. Then starting from the long black line, count the number of black lines it takes to reach the black line which is aligned most closely between the grey lines. Since the count goes downwards, the grey structure is lower than the black structure.



The second example below shows the effect of a misalignment greater than the width of one line but less than the width of a line and space. Notice how there are not enough lines to account for the misalignment. The solution is to wrap around and continue the count. Make sure only to count one of the end lines of the black structure and not both. Since the line count goes upwards, the result shows that the grey structure is shifted up by 0.14 inches.



The final example below shows a misalignment of greater than a line and a space. The process is the same as determining any other misalignment except that you need to add the additional line and space width to the offset. This is useful for applications in which the misalignment is very

large. For such an application, it is useful to lengthen the grey structure. In this way, you can measure large distances very accurately. The total misalignment for this example is -0.04 inches from counting lines and an additional -0.2 inches from the line and space widths for a total of -0.24 inches.

-2 lines x 0.02 inch/line + 2 x 0.1inches = -0.24 inches

Included in the postscript and PDF files are the left and right sides of a vernier for you to practice with before looking at your wafer under the microscope. The examples shown are of course ideal. You will notice that the vernier lines are not as clear on your wafer due to over and underetching. You will have decide where the vernier is aligned. It may be difficult at first, but you will get used to it. Some of your measurements will look like any of three lines could work. This may trouble you at first. Just remember that this resolution is still much better than measuring misalignment with the graduated scales on the microscopes.

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