OP-N: Junction Depth Measurements

filename: JUNCTD

The determination of junction depth is an important aspect of semiconductor process evaluation. In our lab the junction is a result of the pre-dep and drive-in processes performed at high temperature. Although there are a variety of models that can be used to estimate the distance over which the impurities diffuse, and thus determine junction depth, there are also many severe assumptions that must be made to apply the models. It is always desirable to actually measure the junction depths; however, when considering that the distances to be measured are only about a micron, and that impurity concentrations to be sensed are perhaps only 10^{-8} of the semiconductor atomic density, such measurement presents a non-trivial challenge.

Fortunately, there is a relatively simple technique for junction depth measurement which makes use of a mechanical grinding process combined with differential chemical staining. The objective of the grinding process is to convert very shallow depth information into large lateral variations. Figure 1 below illustrates the geometrical advantage of grinding a groove into the surface of our doped chip. W_2 and W_1 are measured with a microscope (see OP-S, p. 190 for line width measurements).

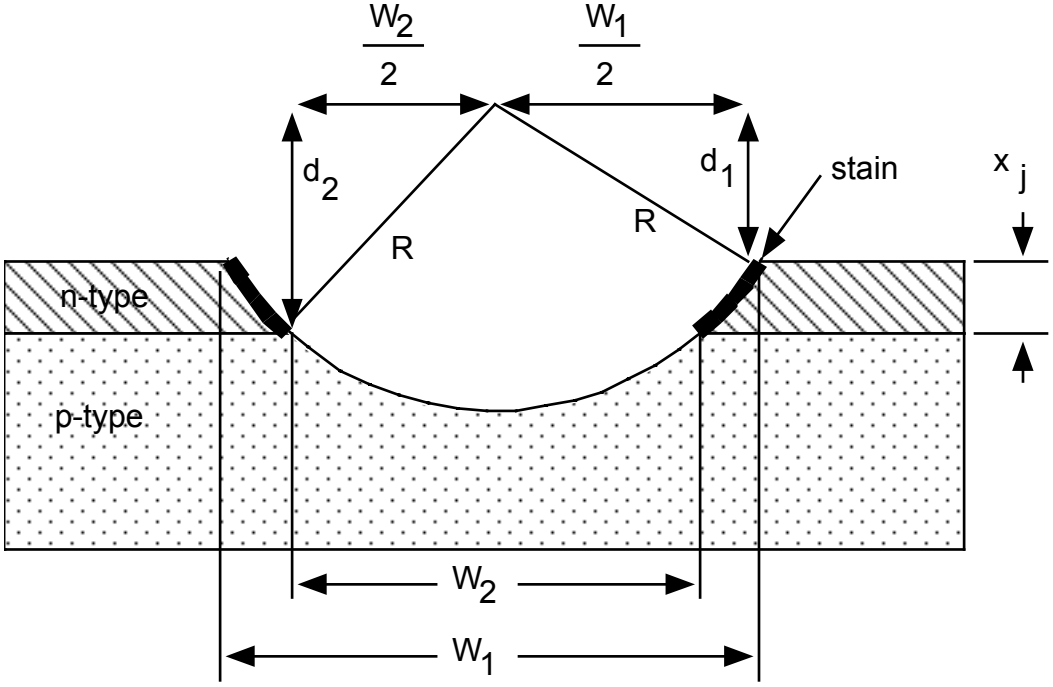

Figure 37: Junction sectioning geometry.

Because of the large radius of the grinding tool, the lateral dimensions which are exposed are quite large. If a chemical stain (consisting of metal salts in an electrolyte) is applied to the exposed p-n junction, and then exposed to light, a preferential staining of the n-type regions will occur. An optical microscope (see OP-S p. 190 for instructions on the

use of our line width measuring equipment) can then be used to measure the two dimensions W_1 and W_2. Applying some geometry yields the relationship:

$$x_j = d_2 - d_1 = \sqrt{R^2 - \left(\frac{W_2}{2}\right)^2} - \sqrt{R^2 - \left(\frac{W_1}{2}\right)^2}$$

At present we use a PHILTEC 2015 Sectioner, with a tool radius R of 19,050 μm. In addition, Philtec has determined that a slight correction factor is necessary to match the results with ASTM standards. Thus, the formula used to determine junction depth is given by:

$$x_j\ (\mu m) = \sqrt{(19{,}050\ \mu m)^2 - \left(\frac{W_2\ (\mu m)}{2} - 9.924\right)^2} - \sqrt{(19{,}050\ \mu m)^2 - \left(\frac{W_1\ (\mu m)}{2} - 9.924\right)^2}$$

Operating Procedure

The basic operation of the Philtec Sectioner is quite simple. The main parameter that must be determined in our application is the sectioning time (see step 8 below). This time is dependent mainly on the type of diamond grinding paste used to dress the spindle (see section 4 below). The operating procedure given on the next pages is a copy of the Philtec instruction sheet. We will give an update on operation in the lab during which you actually perform the junction grooving.

As of Aug. 25, 1988 the following parameters produced acceptable results:

Sectioning time: 10 sec
Staining time: 10 sec
Illumination source: Stereozoom 7 scope, 5X, illuminator power supply setting 3