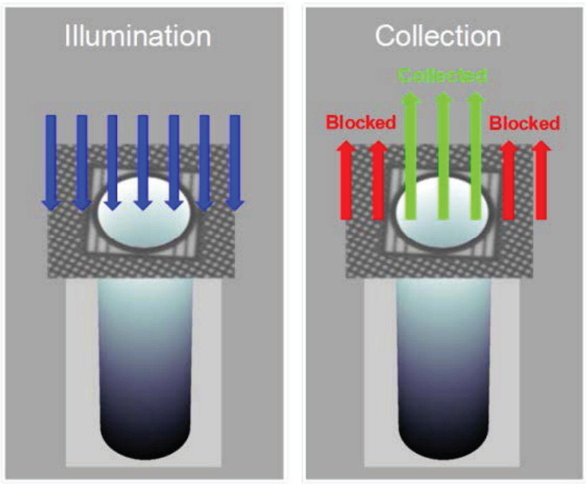
Dark-field Reflectometry

Reflectometry is an incredibly powerful tool, allowing accurate metrology of nanometer-scale structures. However, in some cases the reflectometry signal has weak sensitivity to parameters of interest. Such parameters are called 'weak parameters', and pose a significant challenge to OCD. Another typical problem is when different geometrical parameters of the sample affect the measurements in a similar way, so that deducing their separate values becomes difficult.

Commonly, these types of difficulties are handled by utilizing additional measurement channels, such as measuring reflection from both TE and TM polarizations and measuring reflections at oblique angles. These additional information sources provide independent characterization paths for the sample properties.



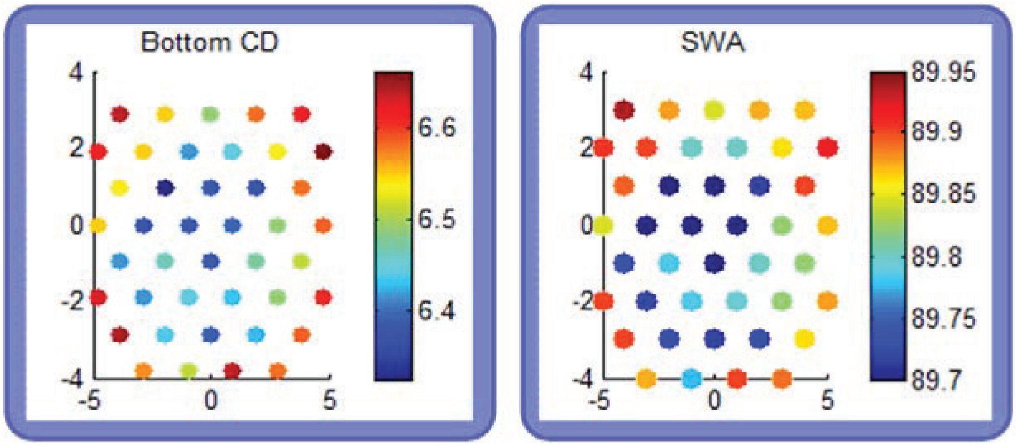
In order to further increase the variety of independent channels, we implement measurement schemes based on the notion of dark-field (DF) detection. In DF measurements, the optical system is designed so that light going through 'simple' reflection from the sample is blocked before detection. The meaning of 'simple' here depends on the specific type of obstruction used on the light return path, which can have several common variations:

- **Dark field by wavelength:** In which the sample is illuminated with one wavelength, while a different wavelength range is detected. Examples are photoluminescence, extensively exploited in biological samples, and Raman spectroscopy.
- **Dark field by specular reflection:** In this set of methods, light that has gone through specular (mirror-like) reflection from the sample is blocked. There are different optical schemes implementing this principle. A common example is DF by angle-of-incidence, in which the sample is illuminated at some direction, and the detector is not placed at the specular direction. Other methods are DF by polarization or phase-contrast illumination, which similarly allow for isolation of non-specular reflection.

Dark field systems are especially useful for measurement of samples that are embedded inside a uniform bulk, such as Through-Silicon-Via (TSV). As light is illuminated onto the wafer, a considerable section is reflected from the area surrounding the via. However, only a small part of the reflected light has undergone interaction with the via side walls, and consequently the reflected signal does not carry clear information.

In order to isolate and highlight the signal related to reflection from TSV side walls, we implemented a dark-field method by which all light specularly reflected from the wafer top surface is blocked, and only light that has entered the via is collected for analysis. This method proves extremely beneficial for the characterization of the TSV profile, allowing extreme sensitivity to the via side walls and bottom characteristics.

Similarly, it is possible to apply the same dark-field measurement scheme to standard OCD applications, where, on many occasions, sensitivity to 'weak parameters' is heightened and correlations between parameters are removed, allowing accurate metrology.



TSV profile characterization using dark-field reflectometry.
Results are obtained by fitting the measured dark-field spectrum to a model.