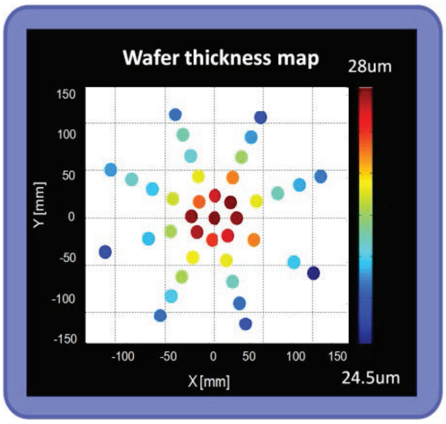
Thickness and Depth Measurements

While characterization of thin films is common practice for many optical techniques, the challenge of accurately measuring large thicknesses poses a difficulty with its own unique aspects.



Thinner wafer thickness map

These types of measurements are important, for example, when characterizing wafer thickness during thinning processes. In this case, as the wafer is thinned to several tens of µm, an accurate monitoring of thickness variations is important.

Another example of where these types of measurements are important is in the accurate characterization of Through-Silicon Via (TSV) depth. TSVs are electrical interconnects planned for next-generation devices, where multiple semiconductor chips will be vertically stacked. The ability to use these short dense interconnects between different layers is expected to provide extremely effective 3D packaging, allowing improved functionality of the device. However, TSVs are only a few microns in diameter and many tens of microns in depth, and are consequently difficult to measure with standard optical tools (which commonly target significantly shallower structures).

Reflectometry is especially suitable for this kind of measurement. Light is reflected from the two surfaces (either the two wafer sides or from the wafer top and via bottom, as shown in the figure below), and interferences are incurred upon collection. Light going through the longer path acquires an additional phase[1]. This phase difference leads to an oscillatory behavior of the reflected intensity, with a frequency directly related to thickness.

[1] This phase difference is given by $2Ln \cdot 2\pi/\lambda$, where λ is the wavelength, n is the refractive index (n=1 for TSV, while $n=n_{Si}$, (the refractive index of Silicon) for wafers), and 2L is the path length difference between the two reflecting surfaces.

An important attribute of this measurement scheme is that the thickness is extracted using **first-principles arguments**, and does not involve any comparison to a pre-calculated model (as in common OCD applications). Information on the oscillations is collected from a broad spectral range, allowing highly accurate identification of the underlying frequency.

This method is very robust, relatively insensitive to details of the measured application, and allows precisions of a few tens of nm. Furthermore, no prior knowledge of the measured sample is required, so that samples of a few µm thickness or depth are measured through the exact same scheme and algorithmic analysis as those with depths exceeding **100µm**. Since no scan is involved in the measurement (contrary to interferometric methods), a reading is obtained with extremely short acquisition times.

This technology is used in the Nova V2600, designed for 3D stacking applications.