N<OVA®
partnering for process control

Multi Channel Reflectometry

Inverse problem - The challenge

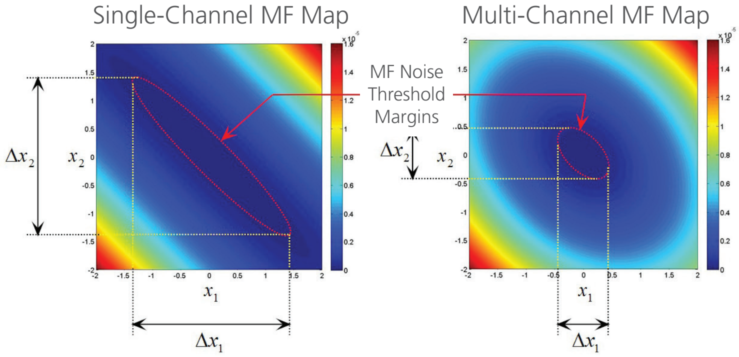
Spectral reflectometry, rely on measuring the scattering properties of the sample to light. Information is extracted by comparing the measurements to known models of scattering, and searching for the one that "best fit" the measurement. This is referred to as solving the "inverse scattering problem", in contrast to the "forward scattering problem" in which the sample properties are given, and its response to light is evaluated. One potential challenge with "inverse problem methods" is uniqueness: The measured data may match more than one possible sample property.

Mutli-channel and its benefits

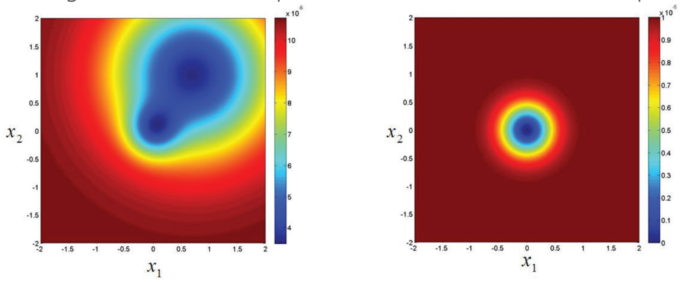
Uniqueness is overcome by collecting **more independent** sets of measurements by the use of **multi channels**.

This approach offers several benefits:

- **Superior accuracy:** The use of multiple data points reduced ambiguity, thus increasing parameter accuracy.
- **Lifting cross-talk:** Multi-channel usually lifts cross-talk between parameters as demonstrated in the figure below, showing the merit-function (measure-of-fit quality) for a 2- parameter sample, measured once with a single channel system, and once with a multi-channel system.



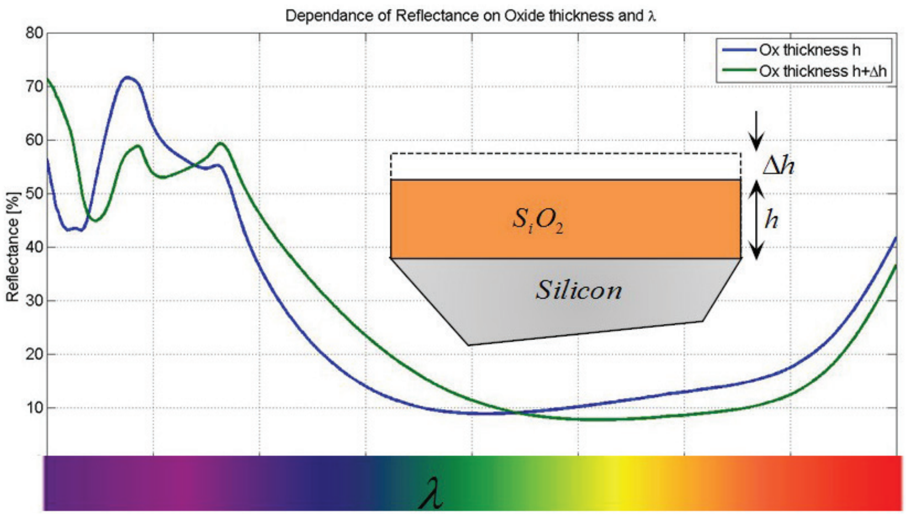
- **Eliminating local minima:** Using multi-channel reduces the chances for an appearance of local minimum, as shown below.



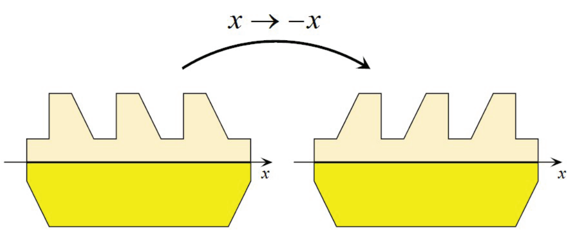
- **Reducing required a-priory knowledge:** With multi-channel, the required a-priory knowledge is reduced as it is already given by the extra set of measurements provided by the multiple channels in use.

How additional information about the sample is gained?

By measuring the sample with an extended set of light properties, such as more **wavelengths**, more **polarization** states, and/or more **angles of incidence** one gets additional **independent** data on the sample. The following figure shows the spectra of a sample (ie the reflectance of the sample as a function of the wavelength) comprising of a silicon dioxide (Sio2, oxide) over silicon for two different SiO2 thicknesses:



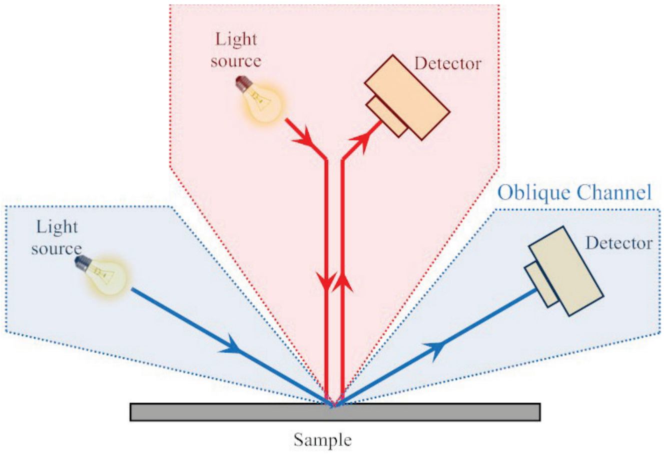
Here, the green wavelength is **insensitive** to the thickness of the oxide. Other wavelengths cover-up for the lack of information. This wavelength however contributes to the identification of another sample property. In a similar manner, the measurement of several **polarization states** and several **angles of incidence** increases the available information about the sample. Use of more than one angle-of not only-incidence is usually beneficial but also **essential**, in cases where the sample has no lateral mirror symmetry (see figure):



When measured with normal angle-of-incidence, the spectral signal signature is identical for both samples. By using oblique angle-of-incidence, symmetry is broken, and the two samples become distinguishable.

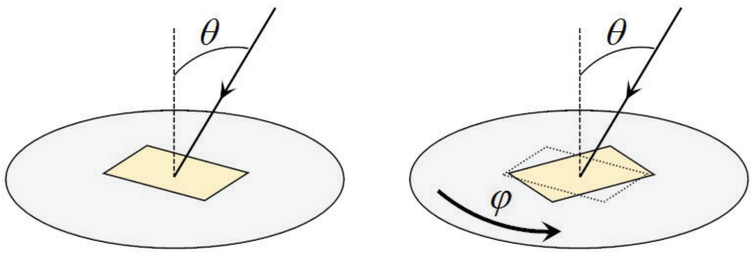
Normal channel, Oblique channel, Azimuth and Heads:

A "channel" is defined as unit capable of measuring spectral reflectance at various polarization states, all with **a single and common** direction of illumination. A system capable of measuring with different directions of illumination is usually more complex and therefore more costly than one with a single direction of illumination. On the other hand, it offers much better accuracy. A typical SR tool having both "Normal" and "oblique" channels is illustrated schematically in the figure below:



In a "Normally incidence" channel, the light illuminates the wafer head-on (also known as the direction "normal" to the plane of the wafer). Systems with normal incidence optics are usually much simpler to design, and are thus cost effective. Normal incidence is considered as the standard channel in spectral reflectometry.

An "Oblique incidence" channel illuminates the wafer from the side at an angle. This angle is carefully chosen to optimize the sensitivity of SR to applications it is intended for. Due to the breaking of symmetry, oblique offers the potential of measuring the sample with different **azimuthal** directions, thus gaining more valuable information (see below).



Each of these two channels usually carries its **own** light source and its **own** detector. These, together with **accurate optical alignment** (that enables both channels to focus onto the same location), facilitates providing high throughput for high-end applications.