SOPRA

APPLICATIONS

## Precise Characterization of

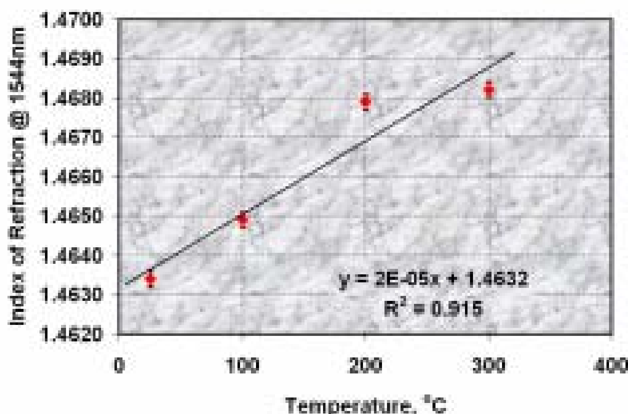
# Optical Waveguide

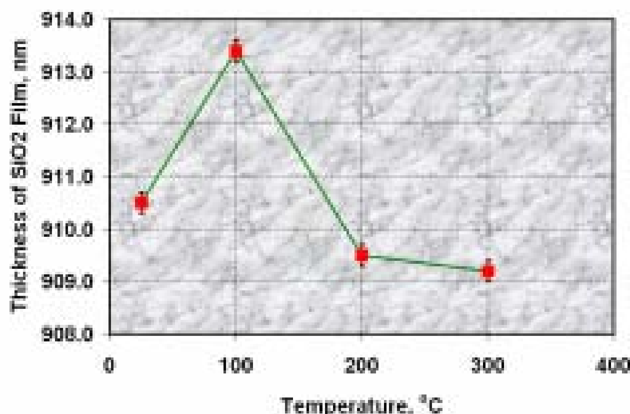
## by Spectroscopic Ellipsometry (SE)

**P**recisely knowing the material optical constants and layer thickness is very important for waveguide manufacturing. Ellipsometry, known as an absolute, non-contact, non-destructive optical technique, has been widely used for precise characterization of thin films layer thickness and material optical constants. The technique determines the changes in the polarization state of the light after its interaction with the sample. A typical ellipsometer comprises a light source, a polarization generator (Polarizer), an Analyzer, and a light intensity detector SOPRA variable angle ***Spectroscopic Ellipsometer (SE)*** operates over a very wide spectral range. It allows very precise and accurate characterization of optical waveguides as shown below.

**Example 1: The following example shows temperature dependencies of both refractive index and layer thickness of a $SiO_2$ waveguide, which was successfully characterized with SOPRA variable angle spectroscopic ellipsometer (Model GES-5). Significant thickness change at 100°C due to moisture and stress effect is clearly identified.**

| Temperature °C | $SiO_2$ Film | |
|---|---|---|
| | Thickness (nm) ± 3σ | N ± 3σ (@ 1544nm) |
| 25 | 910.5 ± 0.7 | 1.4634 ± 0.0007 |
| 100 | 913.4 ± 0.6 | 1.4649 ± 0.0006 |
| 200 | 909.5 ± 0.6 | 1.4679 ± 0.0006 |
| 300 | 909.2 ± 0.6 | 1.4682 ± 0.0006 |




Refer to SOPRA web page ( **www. SOPRA-SA. com**) for tutorial on SE principles, terminology and products.

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**Example 2: Thick waveguide (~ 6 μm) characterized by varying incident angle (@ $\lambda$ = 1550nm)**

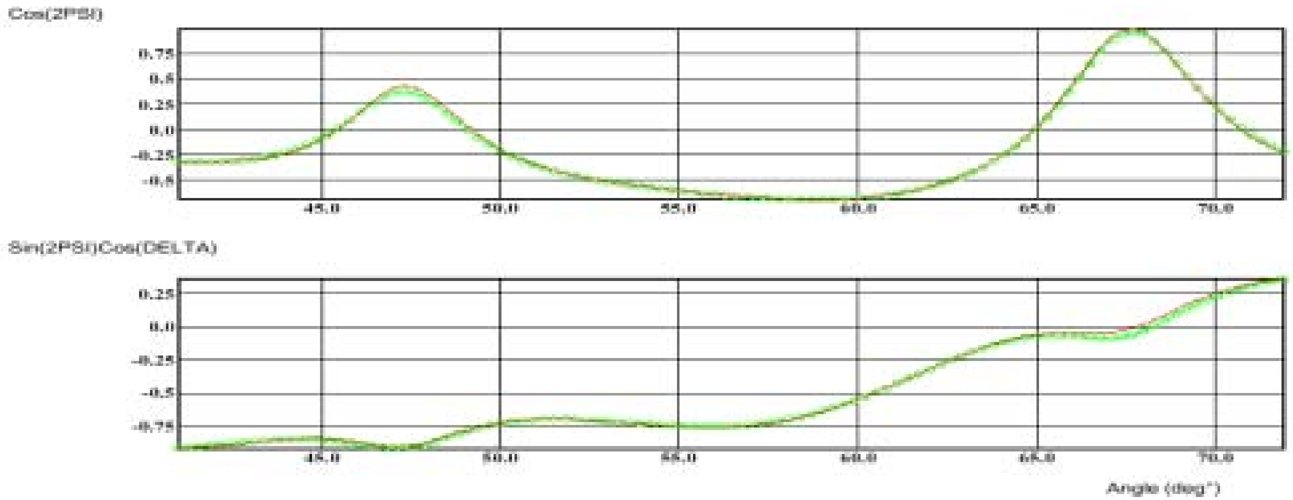


**Table: Repeatability measurements and analysis for $SiO_2$ waveguide**

| Wafer 05 | | Thickness (μm) | | Optical Index (@ 1.55 μm) |
|---|---|---|---|---|
| Center - Repeatability | | | | |
| 1 | | 5.8400 | | 1.45548 |
| 2 | | 5.8399 | | 1.45549 |
| 3 | | 5.8400 | | 1.45549 |
| 4 | | 5.8403 | | 1.45544 |
| 5 | | 5.8402 | | 1.45545 |
| 6 | | 5.8401 | | 1.45546 |
| 7 | | 5.8401 | | 1.45547 |
| 8 | | 5.8401 | | 1.45548 |
| 9 | | 5.8402 | | 1.45547 |
| 10 | | 5.8402 | | 1.45546 |
| | | | | |
| mean | | 5.8401 | | 1.45547 |
| standard deviation | | 0.0002 | | 0.00002 |

**It is shown that SOPRA variable angle spectroscopic ellipsometer offers high precision characterization of both thickness and optical constants. It is essential for waveguide design and process control.**

**Please contact us for more information.**

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