Design of a Simple and Robust Asymmetric Ellipsometer for Terahertz

G. Rana[1], P. Deshmukh[2], S. P. Duttagupta[1], S. S. Prabhu[2]
1. Indian Institute of Technology Bombay, Electrical Engineering, Powai, Mumabai, Maharashtra 400076;
2. Tata Institute of Fundamental Research, DCMP-MS, Homi Bhaba Road Navy Nagar, Mumabai, Maharashtra 400005.

Introduction: Ellipsometry is a well known tool to determine the optical parameters of a certain material. THz being a new research arena many materials are not characterized for their optical parameters in THz.

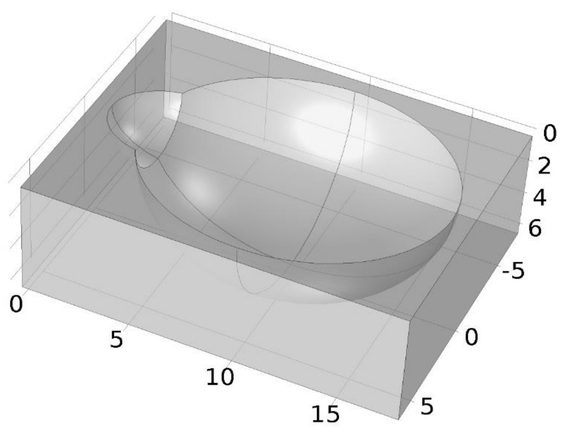

Figure 1. 3D view of the ellipsoid reflector duo

A combination of two ellipsoids with a common focus point can act as an ellipsometer but symmetry in them brings a scan angle limitation to 45°. Our design with two asymmetric ellipsoids has helped us to achieve 65° scan angle.

Computational Methods: The design and simulation has been carried out in Ray optics module. The design being asymmetric provides a huge scope for parametric variation but at the same time analytical approach becomes tedious.

We varied the eccentricities and the major axis lengths of the two ellipsoid but always kept a common focus. In the final design big and small ellipsoids has eccentricity of 0.55 and 0.65 while major axis lengths 8inchs and 4inchs respectively.

The reflecting walls of the ellipsoid are assigned wall condition ‘mixed diffuse and specular reflection’ with probability of specular reflection 1. While the enclosure walls are set with wall condition as disappear. We also clubbed the exact lens configuration for source and detector in the set up.

Results: This design has enabled us to increase the scan angle from 45° to 65°, which is in the typical range of standard ellipsoids operational in optical wavelengths. Among the 65° scan, in one direction the angle limit is 9° while on the other side the scan angle limit is -56°. Unlike the existing designs we need only one rotating stage to rotate the sample about the common focus.

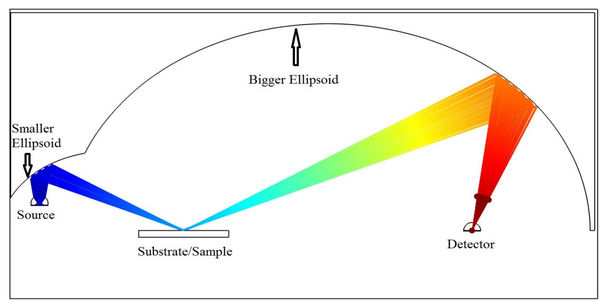

Figure 2. 2D view of the design with ray diagram

Sample at 0°

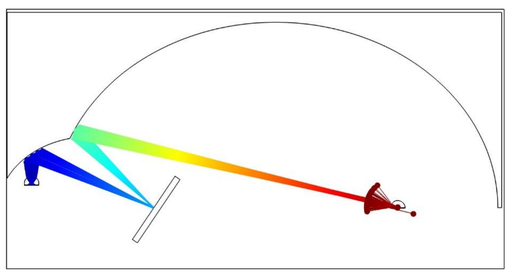

Figure 3. Sample at -56°

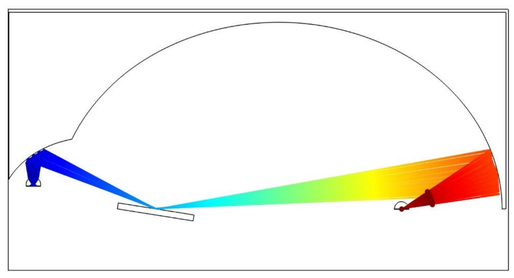

Figure 4. Sample at 9°

Conclusions: The design provides a simple and robust solution for THz Ellipsometry. The design being asymmetric possess a huge scope for tailoring shapes according to ones need. Two reflectors being a single unit, becomes robust and easy to align. Ray optics module provides easy an alternative to the tedious analytical approach arouse due to asymmetry.

References:

1. T. Nagashima and M. Hangyo Measurement of complex optical constants of a highly doped Si wafer using terahertz ellipsometry, Applied Physics Letter, Volume 79 No 24, 3917-3919 (2001)
2. T. Hofmann et. al., Terahertz ellipsometry and terahertz optical-Hall effect, Thin Solid Films, Volume 519, 2593-2600 (2011)
3. T. Hofmann et. al., Variable-wavelength frequency-domain terahertz ellipsometry, Review of Scientific Instruments, Volume 81,023101 (2010)
4. N. Matsumoto et. al., Measurement of the dielectric constant of thin films by terahertz time-domain spectroscopic ellipsometry, Optics Letters, Volume 36 No. 2, 265-267 (2011)