V44

X-ray reflectrometry

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Experiment: November 4, 2024
Submission: November 4, 2024

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Contents

1 Objective

The aim of this experiment is determining the density, thickness and roughness of a thin polysterol film on a silicon wafer. In order to do so, the X-ray reflectivity of the given sample is measured in different configurations and analyzed as described in the following sections.

2 Background

X-rays are a type of ionizing electromagnetic radiation with typical energies in the keV range. Their production inside an X-ray tube relies on the electrostatic acceleration of electrons which then interact with the anode material. The main mechanisms for the emission of energetic photons are the continuous bremsstrahlung resulting from electron deceleration as well as a discrete component emitted after penetration of the inner atomic shells.

2.1 Refractive index

In classical ray optics, the laws of reflection and refraction according to Snell are

$$\theta_i = \theta_r \,, \qquad\qquad n_1 \cos\theta_i = n_2 \cos\theta_t \,,$$

where n_1 and n_2 are the refractive indices of the two media and $\theta_i, \theta_r, \theta_t$ are the angles of incidence, reflection and transmission as shown in Figure 1.

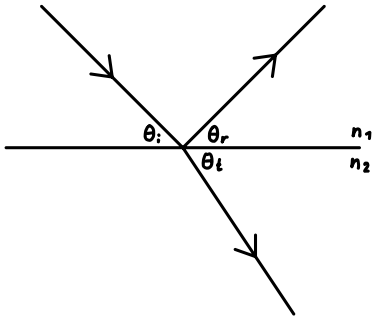

Figure 1: Depiction of reflection and refraction of light rays on a smooth surface.

$$n = 1 - \delta + i\beta$$

2.2 Fresnel coefficients

Fresnel's formulae[1]

2.3 Kiessig fringes

[2]

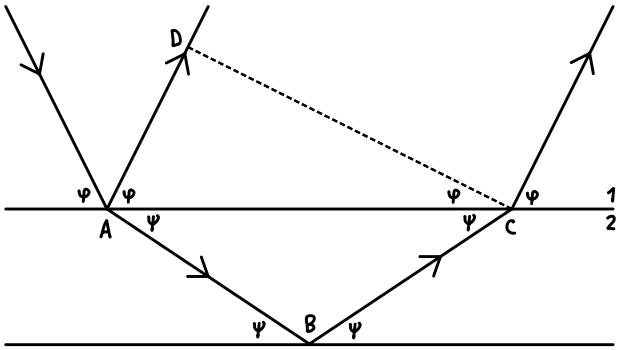

Figure 2: Schematic light paths inside a thin layer atop a substrate producing Kiessig oscillations according to [2].

2.4 Stratified media

[3]

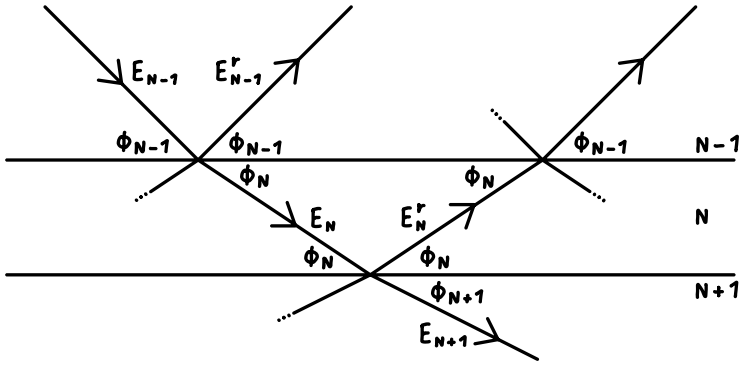

Figure 3: Conceptual visualization of the Parratt algorithm presented in [3].

[4]

[1]Following the derivation in [1] among others.

3 Procedure

4 Results

5 Discussion

References

[1] Jens Als-Nielsen and Des McMorrow. “Refraction and reflection from interfaces”. In: *Elements of Modern X-ray Physics*. John Wiley & Sons, Ltd, 2011. Chap. 3, pp. 69–112. ISBN: 9781119998365. DOI: https://doi.org/10.1002/9781119998365.ch3.

[2] Heinz Kiessig. “Interferenz von Röntgenstrahlen an dünnen Schichten”. In: *Annalen der Physik* 402.7 (1931), pp. 769–788. DOI: https://doi.org/10.1002/andp.19314020702.

[3] L. G. Parratt. “Surface Studies of Solids by Total Reflection of X-Rays”. In: *Phys. Rev.* 95 (2 July 1954), pp. 359–369. DOI: 10.1103/PhysRev.95.359.

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Appendix