

Symmetry of Optical Properties in Advanced Material Physics

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ABSTRACT: Interdisciplinary Optical properties of refractive index, thickness, thin film growth time and Growth rate are measured in Semiconductor Advanced material of Silicon Nitride. Spectroscopic Ellipsometry technique is used in Semiconductor Physics and also in Micro Electronics to characterize optical material properties. It is used to measure thickness range of 50 nm to 250 nm and refractive index range 1.3 to 2.11. Because of its remarkable wear resistance, bone-bonding qualities, and innate capacity to suppress bacterial development, silicon nitride (Si_3N_4) is a high-performance bioceramic utilized in dental, orthopedic, and spinal implants. Because it is totally radiolucent,

CT and MRI scans won't be distorted by it. Important Medical Uses In spinal fusion procedures, spinal implants are frequently utilized as intervertebral spacers. The surface of the ceramic prevents post-surgical infections while promoting bone apposition, or growth directly onto the implant. Joint Replacements: Used in hip, shoulder, and knee replacements. It is extremely resilient to the normal wear and tear of human articulation because of its high fracture toughness and low friction coefficient. Dental implants are a new metal-free substitute for titanium.

Keywords: Optical Properties, Advanced materials, refractive index, Thickness, Growth time and Growth rate.

Introduction: Material Physics is Interdisciplinary field of Science, Engineering and Technology. It is forefront to Nano science and Nano Technology. Material Physics explains about Engineering and Advanced materials synthesis, structure, properties, performance, processing and characterization. This branch explains structure of materials from in Atomic, Macro, Micro and Nano size ranges.

Combining computational methods with Experimental Techniques save and reduce time and effort. Computational material Physics optimize Electrical, Optical, Thermal, Magnetic and Material properties of materials for enhancing applications in Defense, industrial and Medical fields.

Refractive index and thickness of Thin film layers are varied to optimize performance. Refractive index depend on optical path length and reflection properties. Reflected light intensity depends on refractive index and Angle of incidence. Refractive index and Thin film thickness are calculated from Transmittance and Reflection. All advanced materials have significant potential in Opto electronic devices, LED, LASER Diodes, Integrated circuits and Hetero structures. The refractive index and extinction coefficient are related to the interaction between a material and incident light, and are associated with refraction and absorption.

Thin film technology measure refractive index and extinction coefficient over wavelengths as wide as 190-1700 nm - in seconds and with a single mouse-

click. In many cases, our accuracy is even better than much more complicated and expensive ellipsometry method, when the film is absorbing and on a transparent substrate, which is often the case for Si₃N₄, ITO and many other common materials.

- **Methodology:** Semiconductor Physics is significant part of material Physics. Monocrystalline Silicon products are used to produce thin film wafers. It is used in high speed Electronics applications. Advanced material of Silicon Nitride Thin film wafers are used in mobile phones, satellite communications, microwave point-to-point links and higher frequency radar systems.

Spectroscopic Ellipsometry method produce spectral range from 190 nm (UV) to 25 μm (IR). This method is used to measure Silicon Nitride thin film thickness, material refractive index, its extinction coefficient, radiation reflection and transmission, material anisotropy, material

depolarization, radiation scattering, material surface and interface roughness, lateral and vertical

material non-uniformities, Thin film crystal modification, Silicon Nitride composition, Doping

impurities, crystal orientation of organic molecules, electrical and thermal conductivities and material doping profiles.

Table 1: Symmetry between Silicon Nitride Growth time, Growth thickness and Growth rate:

Growth time (Min)	Growth Thickness (nm)	Growth rate (nm/Min)
1	45	80.90
2	50	40.45
3	55	26.97
4	60	20.23
5	65	16.18
6	70	13.48
7	75	11.56
8	80	10.11
9	85	8.99
10	90	8.09

Crystal growth depends on Physical and chemical properties. Crystals are used in Semiconductor Physics, Engineering applications and Opto electronic devices. Thin film wafer growth time is measured after 1 min to 10 minutes. Desired

thickness is observed from 45 nm to 90 nm. Growth rate is decreased from 80.90 nm to 8.09 nm. Highest thickness of 90 nm is observed after 10 minutes

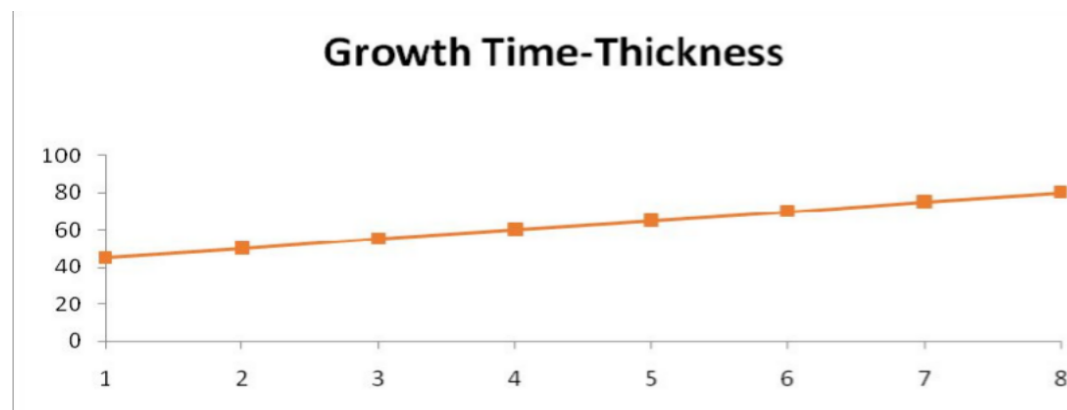


Figure 2 is Graph plot explaining symmetry between Growth time and Thickness. Linear relation exist between Growth time and Thickness

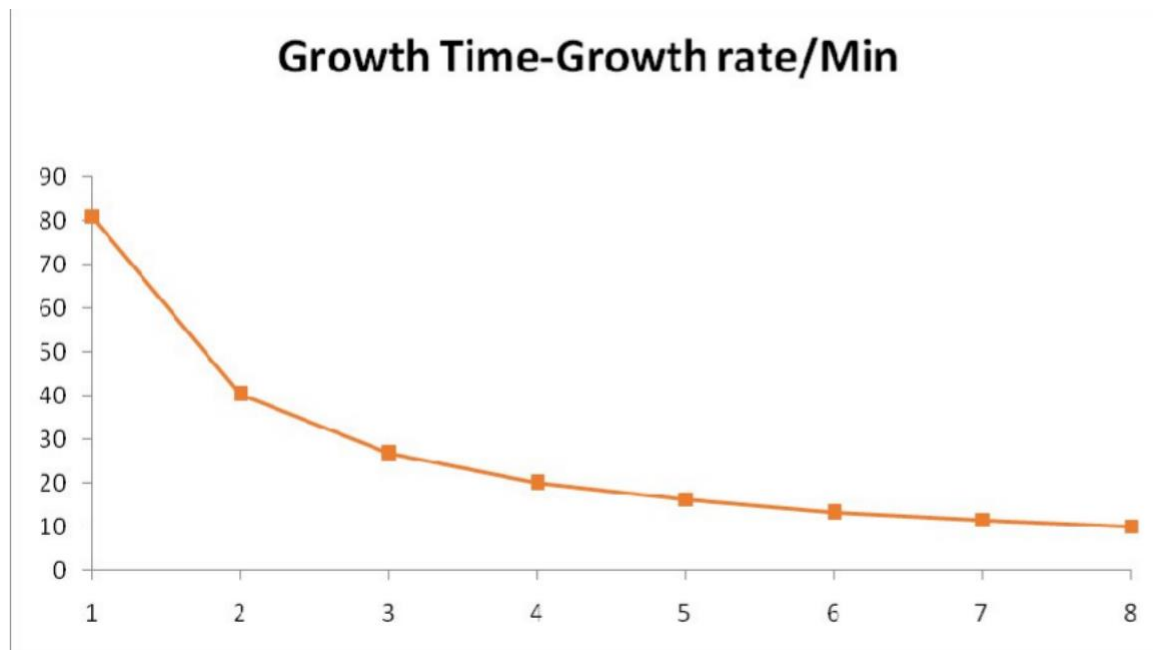


Fig 3 represent Graph plot between Growth time and Growth rate per minute.

Spectroscopic Ellipsometry is high accurate Thin film measurement tool used from basic research to Industrial applications. This method is used to

determine Optical properties of all advanced materials. This graph explains symmetry between Growth time and Growth rate.

Silicon Nitride is most important studied material in Micro Electronics. Wide band gap of this material support large Electric fields. Emerging areas in Ellipsometry explains about Vacuum Ultraviolet

Spectroscopy, Infrared Spectroscopy and Spectroscopy in life sciences

Incidence angle	Refractive index	Thickness (nm)
30	1.95	80.9
50	1.88	81.8
70	1.45	106.5
90	1.29	50.00

Table 2. Symmetry between Refractive index measurement and thickness

Refractive index is measured at different incident angles and observed to vary from 1.95 to 1.29. Highest Refractive index of 1.95 is observed at incidence angle of 30 with film thickness

80.9 nm and lowest refractive index of 1.29 is observed at incident angle of 90 with thickness 50 nm. Normally refractive index should be constant

for every thickness, but this is not the ideal world. In thin films this index dispersion usually is a result of the processing. In other cases the temperature of the substrate sample is gradually raised in sputtering due to hot electrons hitting the substrate and that also changes either composition or morphology of the Silicon Nitride film. It has a direct impact on the refractive index.

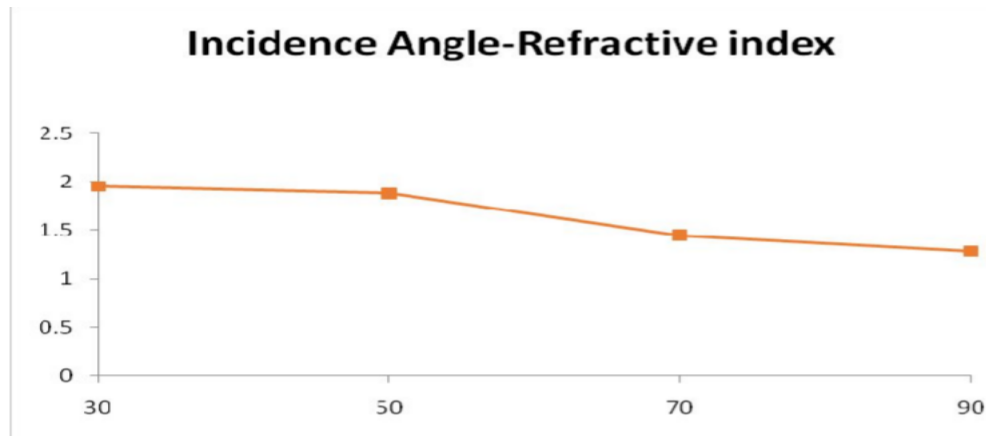


Figure 4 is Graph slot explains symmetry between film Refractive index at different incidence angles. Refractive index is fundamental physical property.

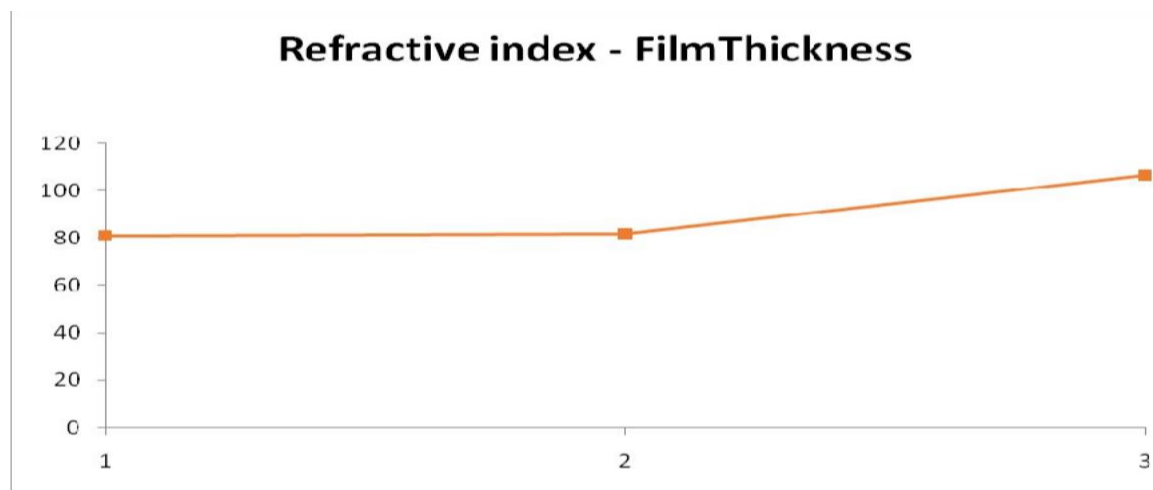


Figure 5 is graph plot to explain symmetry between Refractive index and Film thickness. Linear relation exist between Refractive index and film Thickness.

CONCLUSION: Thin-film technologies reduce the cost of solar cells. Silicon Nitride Thin-film solar cells are cheaper to manufacture owing to their reduced material cost, energy cost, handling cost and capital cost. This is especially represented in the use of printed electronics. Other thin-film technologies are often classified as emerging or third generation photovoltaic cells. They include, organic, dye-sensitized, and polymer solar cells, as well as quantum dot, copper zinc tin sulfide, nanocrystal and perovskite solar cells.

Thin-film printing technology is being used to apply solid-state lithium polymers to a variety of substrates to create unique batteries for specialized applications. Silicon Nitride Thin-film batteries can be deposited directly onto chips or

chip packages in any shape or size. Flexible batteries can be made by printing onto plastic, thin metal foil and paper. Silicon Nitride Thin films are used in Reflection and Optical coatings.

Silicon nitride is used in many Orthopedic and Spinal fusion devices. Silicon Nitride is often used as insulator. Silicon Nitride is produced as thin film only because it is difficult to produce as Bulk material. Ellipsometry is a technique that is often used to measure properties of thin films. In a typical ellipsometry experiment polarized light is reflected off a film surface and is measured by a detector. ρ A model analysis is then conducted in which this information is used to determine film layer thicknesses and refractive indices.

Ellipsometry is accurate technique to measure the refractive index and the thickness of Silicon Nitride thin films. The instrument relies on the fact that the reflection at a dielectric interface depends on the polarization of the light while the transmission of light through a transparent layer changes the phase of the incoming wave depending on the refractive index of the material. It is used to measure layers as thin as 1 nm up to layers which are several microns thick. Applications include the accurate thickness measurement of Silicon Nitride thin films, identification of materials and thin layers and the characterization of surfaces.

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