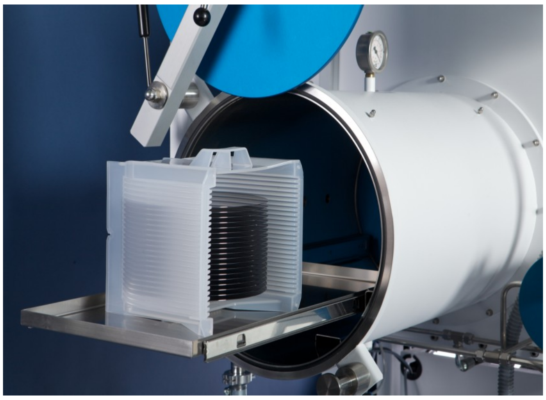
Semilab

PUV Ellipsometer

Introduction

Standard 157 nm F_2 laser sources were introduced in projection lithography as successors to 193 nm based systems. This followed the historical trends in the microelectronic industry where wavelength reduction is used to improve feature resolution. At 248 and 193 nm, spectroscopic ellipsometry has shown to be a very efficient method to characterize photoresists and antireflective coatings. Instrumentation for VUV (vacuum UV) lithography at 157 nm requires special optical setup since O_2 and H_2O are extremely absorbing below 190 nm.



PUV SE manual load lock

PUV SE station

Technological details

The PUV-SE system (Purged UV) has been developed working into a purged glove box to eliminate oxygen and water contamination. The optical setup includes a premonochromator in the polariser arm to avoid photobleaching. The spectral range of the instrument is 140 – 680 nm based on deuterium lamp. The system works in rotating analyser configuration (included optional fixed compensator) to minimize the parasitic residual polarisation. Ellipsometric and photometric measurements versus wavelength and angle of incidence can be performed. Periodic structures and pattern wafers can be characterised by using scatterometry and dedicated focusing optics.

Specifications

Spectral range:	140 – 680 nm
Spectral resolution:	0.5 nm at 145 nm
Incident angle:	30° ~ 90°
Advanced measurement software	
Option(s):	
Focusing optics	
Mapping up to 300 mm	
Fixed compensator option	

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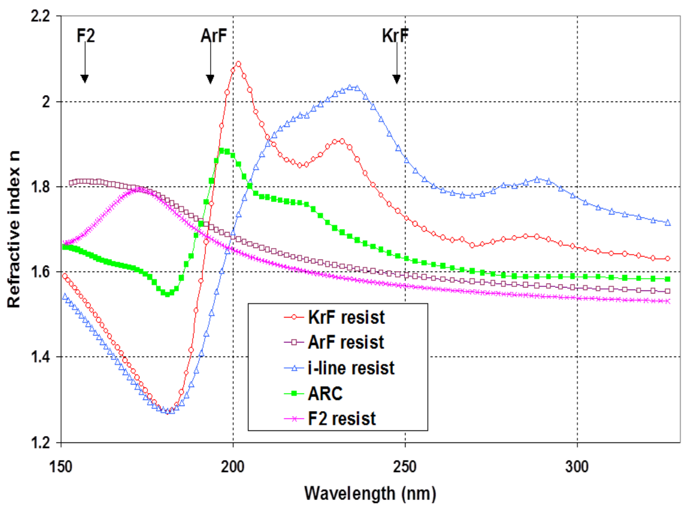
Applications: Photoresist, Bottom and Top AR Coatings, CaF_2

VUV spectrosopic ellipsometry provide accurate characterization of thin film thickness and optical properties near and above the bandgap. It measures a wide photon energy range from 1.82 eV to 9 eV.

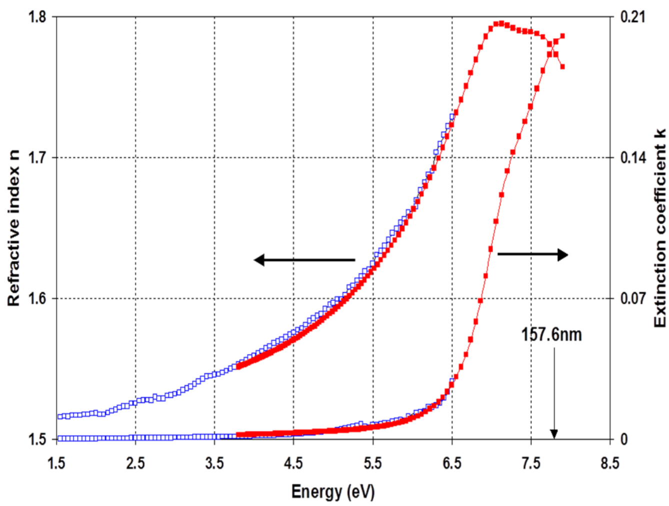
This allows study of the electronic transitions in all types of semiconducting and dielectric films. It offers two advantages for ultra thin film characterization:

Short wavelengths are sensitive to thin layers and UV absorption differentiates materials. From the samples transmitted or reflected intensity can be measured. At any kind of polarizer direction at different angles reflection and transmission can be determined. It has been successfully used to characterize all types of films in lithography, including:

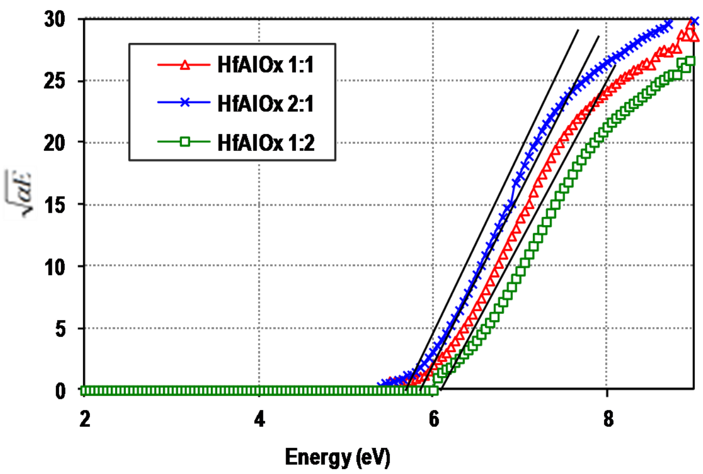
- Photoresists,
- Bottom and Top AR Coatings,
- Photomask Coatings,
- Hardmasks,
- Stepper Optical Coatings,
- Pellicles,
- Optical Materials: CaF_2, MgF_2, LaF_3, etc.



Refractive index of different resists and antireflective coatings



Refractive index of photoresist as measured with PUV and DUV SE



Absorption coefficients for mixed high-κ material: $HfAlO_x$

Optical indices of high-κ materials, eg. SiON, HfO_2, Al_2O_3 and mixed $HfAlO_x$ layers can be precisely determined using Semilab's PUV ellipsometer. Such materials exhibit wide band-gap which justifies the need for characterization systems operating in the VUV (vacuum UV range).

The extinction coefficient can be used to extract the band gap of the different $HfAlO_x$ materials. As shown in the present example (see figure on the left), the band gap of the layer increases with the aluminum concentration [1]. The extracted values are intermediate between those of HfO_2 (5.78 eV) and those of Al_2O_3 (6.26 eV).

References

[1] P. Boher, P. Evrard, O. Condat, C. Dos Reis, C. Defranoux, E. Bellandi, Thin Solid Films **450** (2004) 114

