VUV-VASE

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Ellipsometry Solutions

Accurate

Overview

The VUV-VASE variable angle spectroscopic ellipsometer is the reference standard for optical characterization of lithography films and UV optics. Measuring wavelengths from vacuum ultraviolet (VUV) to near infrared (NIR), it provides incredible versatility. The VUV-VASE allows you to characterize semiconductors, dielectrics, polymers, metals, multi-layers, transparent films, and even liquids. You can also measure polarized reflection and transmission intensity data over a wide angle and spectral range.

Why VUV-VASE

+Wide Spectral Range

The VUV-VASE covers wavelengths from 146 nm up to 2500 nm (0.5 to 8.5 eV).

+High Accuracy

Utilizing our patented AutoRetarder®, the VUV-VASE guarantees accuracy for any sample measurement.

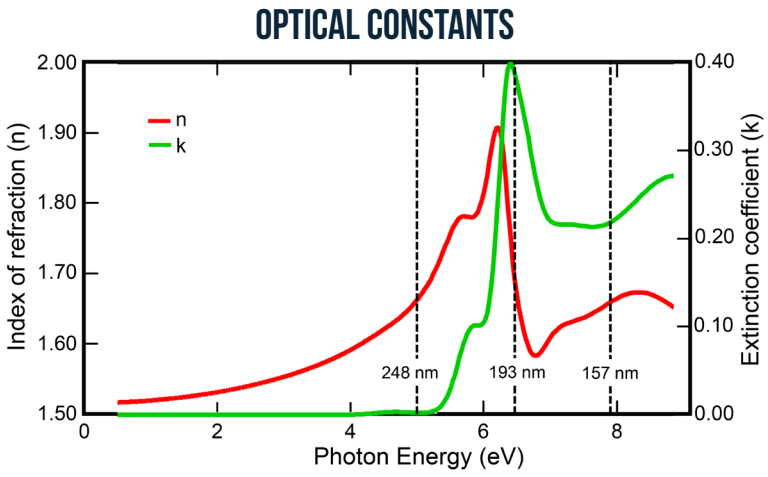
+Convenient Sample Loading

Load-lock design allows fast, efficient sample loading without contaminating system purge.

+Protect Your Samples

The monochromator is placed before the sample to limit exposure of photosensitive materials.

Features



Optical constants for a thin organic film used for photolithography

Wide Wavelength Range

The VUV-VASE can measure wavelengths from 146 to 2500 nm (0.5 to 8.5 eV). Highly reflective samples may even provide data to 140 nm (8.85 eV). Users have control over both wavelength selection and spectral bandwidth, which can be increased to provide higher signal or reduced to resolve fine details.

Nitrogen Purge

The VUV-VASE is purged continuously with dry nitrogen gas to eliminate the atmospheric absorption of light below 190 nm by oxygen and water vapor. The sample chamber is designed to quickly restore the purged environment after the sample is loaded and then reduce flow to save nitrogen when under normal operation.

Load-Lock Sample Chamber

Samples are conveniently loaded without reducing purge quality throughout the instrument via a load-lock surrounding the sample region.

Automated Sample Alignment

Load your samples and the stage automatically aligns to ensure proper sample placement (tip-tilt-z).

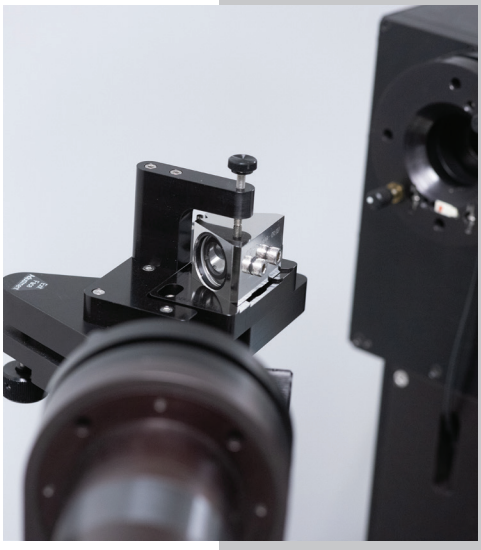
Non-Destructive Materials Analysis

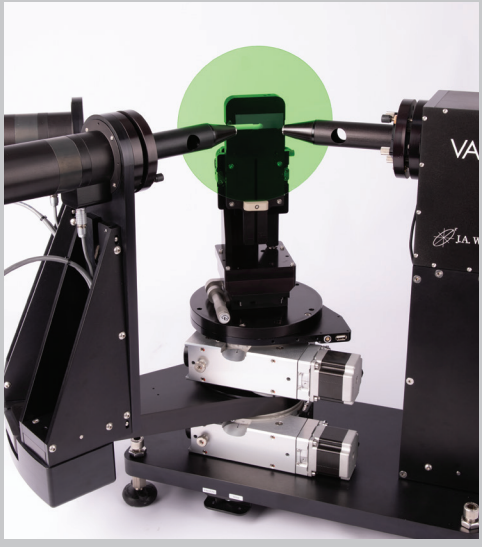
The VUV-VASE offers non-contact, non-destructive measurements of material properties. The monochromator is located before the sample, which restricts the intensity of light incident on the sample to a very narrow bandwidth around the wavelength being measured. This avoids photo-bleaching of light-sensitive samples, as can happen for other ellipsometers where the monochromator is placed after the sample.

Advanced Measurements

Mueller Matrix & Generalized Ellipsometry

Ellipsometry is a non-contact, non-destructive optical characterization technique that measures the change in polarization of light upon reflection from or transmission through a sample. The change in polarization caused by a sample is typically reported as Ψ and Δ for isotropic samples. However, Generalized and Mueller Matrix ellipsometry are not limited to measuring isotropic samples where film thickness and optical constants are the primary interest. By measuring the Mueller Matrix, we can characterize the most advanced materials. Some examples include arbitrarily anisotropic, crystalline substrates and films, birefringence in stretched polymer foils as found in roll-to-roll applications, polarization filters in AR/VR devices or cameras, entire liquid crystal cells, oriented nanostructures, metamaterials, or periodic 3D-structured materials. The Mueller Matrix contains all essential optical information, including intensity propagation, cross-polarization due to linear and circular birefringence, linear and circular dichroism, and phase retardance. Essentially, any optical effect possible will be described by the Mueller Matrix.





Transmission, Reflection & Minimum Deviation

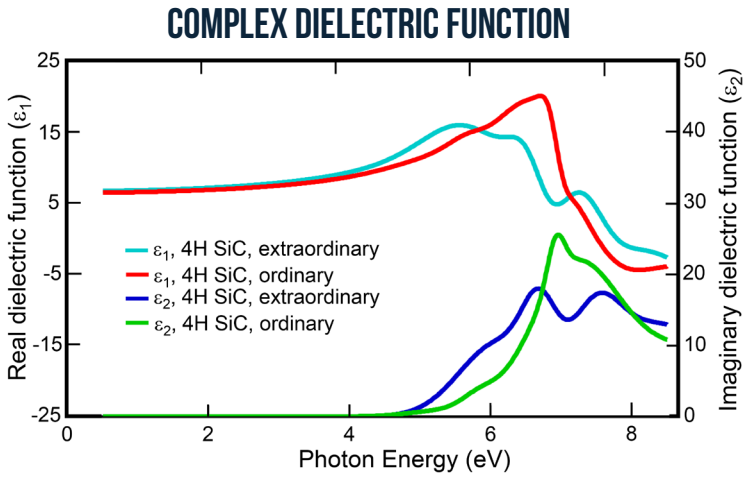
The VUV-VASE can be used to acquire various intensity-based measurements, such as reflection, transmission, and the minimum deviation angle of a beam through a prism. Since the VUV-VASE contains a vertical sample mount, it is ideal for these measurements. Transmission and reflection measurements can be analyzed with ellipsometry data to increase sensitivity and break the correlation between thickness and absorption. The VUV-VASE features automated interleaving technology to ensure the intensity baseline measurement is fresh and consistent throughout the scan.

The VUV-VASE is also well-suited for the prism minimum deviation technique. Refractive index can be measured using this technique on solid materials, such as bulk transparent glasses. This technique is also commonly used for measuring the refractive index of liquids. To determine the refractive index of liquids using the minimum deviation procedure, the liquid is contained in our custom-designed hollow prism cell. Measurements are made through transparent windows of CaF_2 or high-purity fused silica. Light passing through the prism is refracted and the angle of refraction can be used as a measure of the refractive index. Furthermore, the extinction coefficient can be determined by measuring the liquid at multiple locations along the prism, providing different path lengths, and calculating a ratio of intensities.

Benefits

Vacuum UV Spectral Range

Many materials have interesting optical properties at higher photon energies where their electronic band structure can absorb light. The VUV-VASE is well-suited for measuring these optical properties for all materials, even anisotropic materials that have directional dependent optical properties.

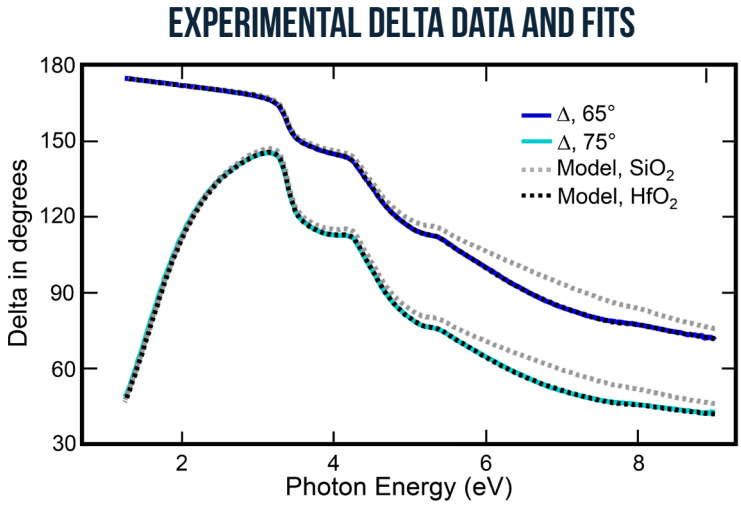


Anisotropic dielectric function for 4H silicon carbide measured with the VUV-VASE

Ultra-Thin Films

The short wavelength capability of the VUV-VASE is beneficial when measuring very thin nm-scale films. At VUV wavelengths, there is higher sensitivity to the thickness and refractive index, which is not available at visible and near infrared wavelengths.

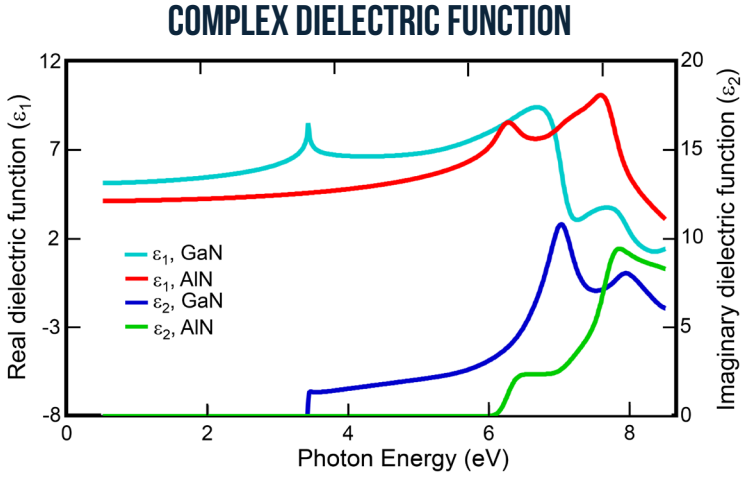
The measured Delta data shown are from a 4 nm thick high-index dielectric film on silicon. The model using transparent SiO_2 with lower index does not match the data at higher photon energies, whereas the HfO_2 model does match data at all wavelengths. This demonstrates that there is sensitivity to both the higher index of refraction and the absorption at VUV wavelengths.



Ellipsometric delta data collected from a very thin (4 nm) hafnium oxide thin film. Data in the VUV helps determine the correct refractive index.

High-Bandgap Materials

The VUV-VASE measures a very wide photon energy range from 0.5 to 8.5 eV. This allows study of the electronic transitions in all types of semiconducting and dielectric films. The high energy electronic transitions of group-III nitrides affect the VUV dielectric functions as shown.

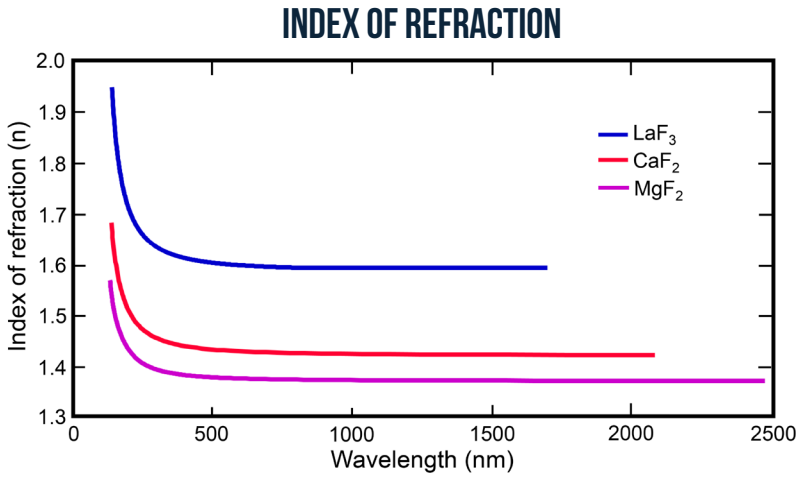


The VUV-VASE is useful for studying the band structure of semiconductors at high photon energies. Shown are the dielectric function of GaN and AlN measured to 8.5 eV.

Applications

Deep UV Optical Coatings

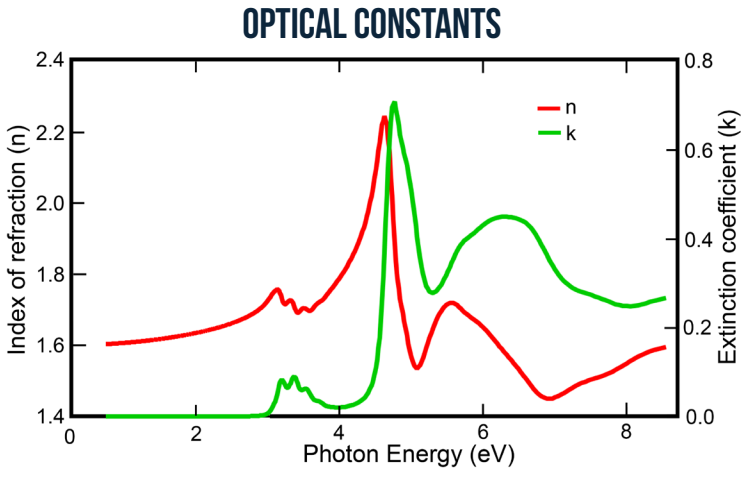
Optical elements used in the VUV can be enhanced using optical coatings. Coating performance depends on refractive index and thickness. Fluorinated materials remain transparent into the VUV, and the index for various fluorides measured with the VUV-VASE is shown. In addition, the VUV-VASE can measure transmitted intensity to characterize low-level absorption at VUV wavelengths. The VUV-VASE is also used to study coating damage from irradiation, which can induce surface damage and bulk damage.



Index for fluoride materials measured with the VUV-VASE

Lithography: Polymer Photoresist Film Optical Constants

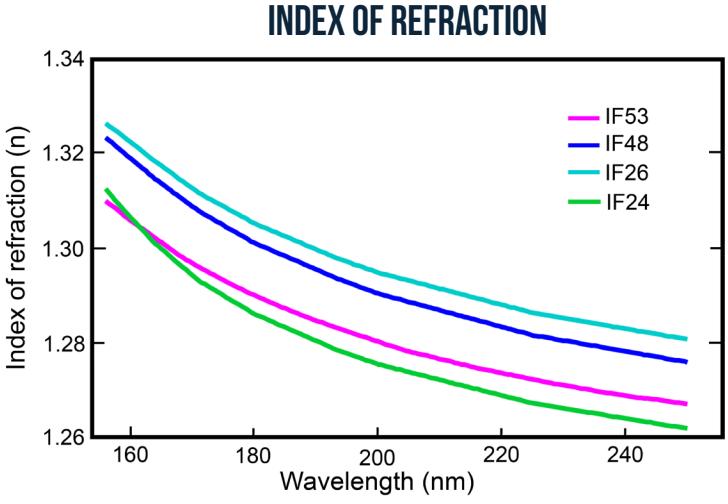
Lithography thin films were an important motivation for the VUV-VASE development. Polymers and photoresist films are still important at short wavelengths. The VUV-VASE provides excellent characterization capabilities at 193 nm (6.42 eV) for current lithography applications because data can be collected surrounding this wavelength to ensure correct modeling for most accurate n and k values.



Optical constants measured for an organic photoresist

Liquid Optical Properties

The VUV-VASE can be enhanced with a hollow-prism cell and special measurement algorithm to determine the optical properties of a liquid. This is achieved via the minimum deviation method. Results are shown for a series of UV-transmitting liquids.



Index for various immersion fluids measured with the prism minimum deviation method on a VUV-VASE

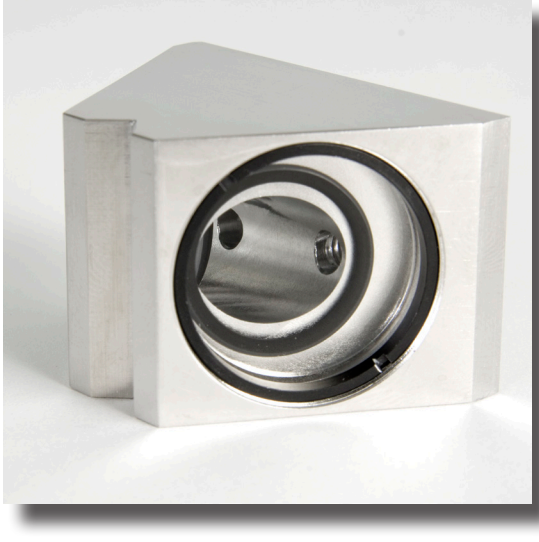
Gen-I

The VUV-VASE Gen-I is perfect for new materials research and can accommodate samples up to 200 mm diameter.

Sample Carousel

Save time loading samples and purging the load-lock by using a sample carousel.

+ 25 mm sample carousel holds 15 samples, 25 mm diameter, 3 mm thick
+ 12.5 mm sample carousel holds 30 samples, 12.5 mm diameter, 3 mm thick
+ Carousel alows both reflected and transmitted data acquisition.



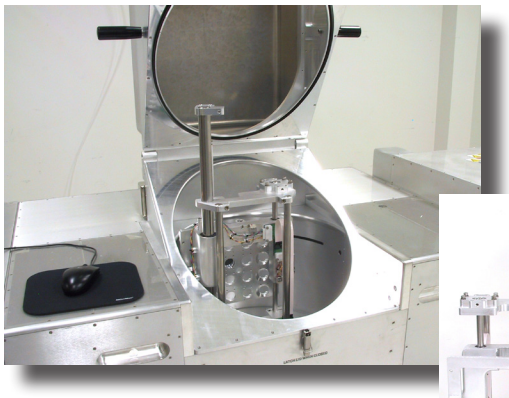
Prism Cell

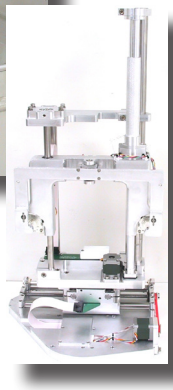
Add a hollow prism cell accessory to determine optical properties of liquids using the minimum deviation technique. Compatible with Gen-I and Gen-II.

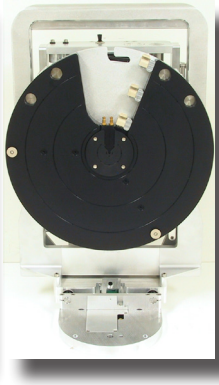
+30° cell
+60° cell

Gen-II

The VUV-VASE Gen-II combines all the features and capabilities of Gen-I with optional mapping or cryostat capability.







Mapping

Add XY or R-Theta mapping:

+140 x 140 mm XY: reflection and normal incidence transmission capabilities across center; designed for photomasks or 16 discrete 25 mm diameter samples
+300 mm R-Theta: reflection only

Cryostat

Add a cryostat to allow for measurements at variable sample temperatures. Windows in cryostat chamber limit measurements to 70° angle of incidence. Customer supplies liquid He (4.2 K) or Liquid N2 (77 K) for low temperatures.

+standard: 4.2/77 – 500 Kelvin
+optional: 4.2/77 – 800 Kelvin

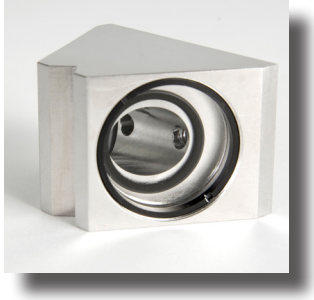
Atmospheric Cell

Add the atmospheric cell to perform measurements in an inert atmosphere or mount air-sensitive samples away from the ellipsometer to transport for measurement.

Prism Cell

Add a hollow prism cell accessory to determine optical properties of liquids using the minimum deviation technique. Compatible with Gen-I and Gen-II.

+30° cell
+60° cell



Specifications

Spectral Range

Standard 146 to 1100 nm

+XNIR extension 1100 to 2500 nm

Angle of Incidence

Fully automated. Ranges below:

Gen-I 10° to 90° (wavelengths <290 nm)
25° to 90° (wavelengths >290 nm)

Gen-II 10° to 90° (wavelengths <315 nm)
20° to 90° (wavelengths >315 nm)

System Configuration

Rotating Analyzer Ellipsometry (RAE) with patented AutoRetarder®, and automatic wavelength selection via monochromator

Data Acquisition Rate

+Typical: 1 to 3 seconds per wavelength*

+High Accuracy: 20 to 30 seconds per wavelength*

*Depending on reflectivity of sample; dynamic averaging feature automatically adjusts aquistion time for each wavelength based on reflected intensity

Software

WVASE for data acquisition, data analysis, and optical simulations

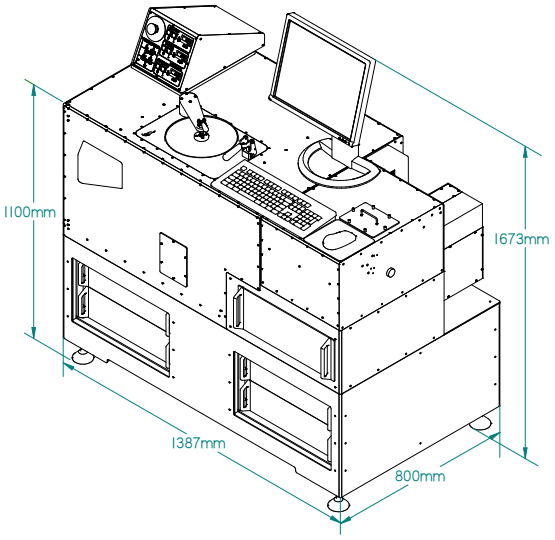
Light Source

Deuterium + Xenon lamps

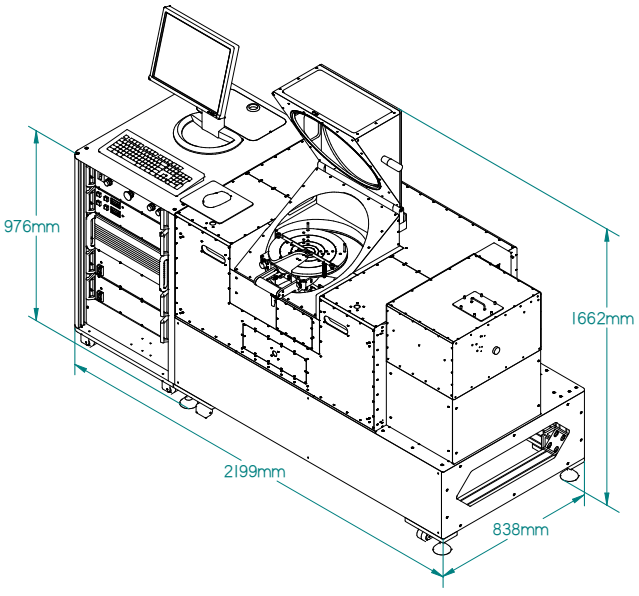
Power Requirements

100 - 120 VAC/15A, 200-240 VAC/8A

Gen-I Dimensions

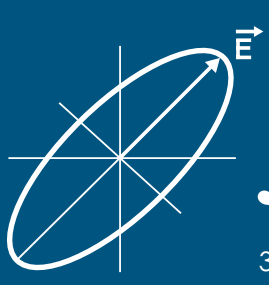


Gen-II Dimensions



Versatile

For more information:



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