Self-consistent optical-constant of materials for EUV multilayer coatings

Juan I. Larruquert, Luis V. Rodríguez-de Marcos, José A. Méndez, José A. Aznárez
GOLD, Instituto de Optica-CSIC, Madrid

The preparation of multilayer coatings relies on the availability of precise optical constants of thin-film materials. When these are available, often they are not self-consistent, because they are obtained either on a narrow spectral range or by aggregation of data from different sources. Self-consistency requires that *n* and *k* be connected with the Kramers-Kronig (KK) relations.

At GOLD we have been obtaining self-consistent optical constants of several thin-film materials, mostly following two procedures:

a) Transmittance measurements versus energy in a broad spectral range for various film thicknesses. This provides k at each photon energy, and n is calculated with KK analysis.

b) Combinations of measurements including transmittance, reflectance, and ellipsometry in spectral intervals jointly covering a broad spectral range. Starting with these measurements, an iterative double Kramers-Kronig analysis procedure is followed: a first one on reflectance and its phase and a second one on *k* and *n*.

Measurements from the near infrared down to a wavelength of 30 nm (up to 41 eV) in the EUV can be performed at GOLD, as well as ellipsometry in the 190-950 nm range. To cover shorter wavelengths (larger energies), we have used BEAR-Elettra and 6.3.2-ALS synchrotron beamlines in collaboration with various groups in Italy and USA.

Self-consistency of *n*-*k* data generated with either procedure is tested with the use of two sum rules. Typically, the self-consistency of optical-constants is globally evaluated over the whole spectrum with these sum rules. We have generalized this evaluation to obtain also the local consistency of the optical constants at each photon energy range through a novel sum-rule method which includes window functions.

With the above procedures, various sets of materials have been characterized, including a long series of lanthanide and alkaline-earth metals, along with various carbides, fluorides, oxides, and boron. We will display examples of optical constants and self-consistency tests of interesting materials for multilayers in the EUV and adjacent ranges.