Measurement of the complex refractive index in the UV range with ellipsometry

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The complex refractive index is a fundamental material property. It is still not well known in the ultraviolet (UV) range. Because UV lasers are increasingly used for industrial material processing and ophthalmology, the complex refractive index of solids has been measured with two types of ellipsometers.

Introduction

With ellipsometry (Figure 1), the complex refractive index (refractive index and absorption coefficient) of a material can be determined. The method is based on the change of polarization when light is reflected on the material's surface. Using a spectrometer, the wavelength dependence of the complex refractive index can be retrieved as well. The materials analyzed here are Au, N-BK7, fused silica, PMMA and Al.

Motivation

The main objective of the work is to find the optical properties of PMMA in the UV range. These results will allow to cut PMMA with a UV laser. The measurement of the other materials has provided experience in measurement and analysis. The application of those results will mainly be used in the medical field.

Methods

Measurements were made with two Ellipsometers: A commercial instrument by the J.A. Woolman company (M-2000X-210, 210 nm to 1700 nm bandwidth, 2.1 nm resolution) and an instrument developed at BFH (190 nm to 300 nm bandwidth, 55 pm resolution). The angle of incidence of the light beam was varied from 70° to 80° to have an optimal signal-to-noise ratio.
In a first step, the surface roughness of the sample was not considered. In a second step, the effective medium approximation (EMA) was introduced to take the surface roughness into account. Roughness measurements were performed with the NaniteAFM atomic microscope by the Nanosurf company. The surface roughness was found to be in the order of 5 nm.

Results

Special care was taken to control critical parameters such as the angle of light incidence, dirt on the material under analysis, the roughness of the material, etc. In addition, approximations were applied to create an enhanced optical model. The results were analyzed with MATLAB. The measurements obtained with the two ellipsometers were compared with each other and with literature values. Being the first measurement at such low wavelengths, a comparison value was not found. However, the two ellipsometers were in good agreement.

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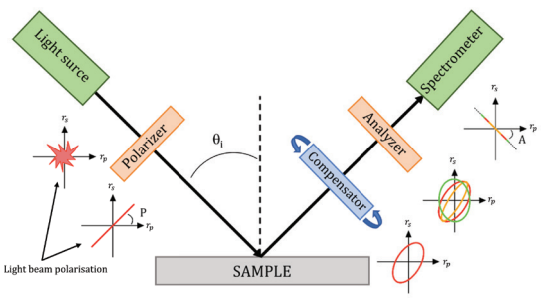

Figure 1: Functional diagram of an ellipsometer.

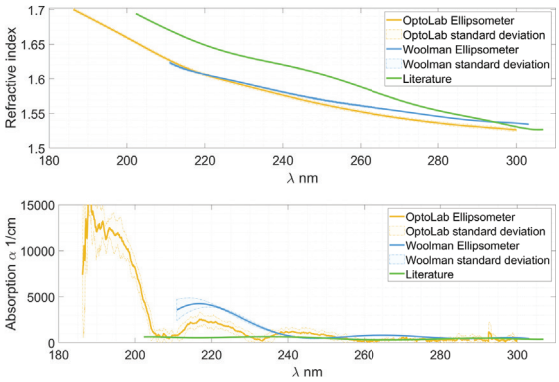

Figure 2: Refractive index and absorption coefficient for PMMA.