Spectroscopic Ellipsometry Metrology of Precision Optical Surfaces and Thin Films

V. Azarova, A.Kulagin, V. Fokin
R&D I “Polyus”
3, Vvedensky str., 117342, Moscow, Russia
azarova_v_v@mail.ru

Abstract—There are analyzed spectroscopic ellipsometry (SE) and variable angle spectroscopic ellipsometry (VASE) light measurement methods. These methods are nondestructive powerful technique to investigate the optical response of materials and to measure simultaneously the layers thickness, composition and dielectric parameters of multilayer systems.

Keywords—thin films, optical surfaces, SE and VASE measurement methods

The modern methods of spectroscopic ellipsometry (SE) and (VASE) are considered. The opportunity to test a value of surface destroyed layer and quality of surface cleaning is discussed. The ellipsometrical measurement methods for using at technology processes of thin dielectric films production are analyzed. It is shown that these metrological methods are very useful for study thin films parameters. Dispersion functions of complex refractive index \(n(\lambda)\), \(k(\lambda)\) and thickness \(d\) can be measured with help of spectral many angles ellipsometrical method.

Measurement results of thin films parameters from laser mirrors [1] materials Ta2O5 before and after reoxidation are shown as an example. Interesting that mirror losses through film absorption can be decreased more than three times for \(\lambda=632\text{ nm}\).

Also in this work the comparative parameters of gradient thin films (Nb2O5 and SiO2) measured by VASE are discussed. It is shown that by moving the substrate between two targets Nb and SiO2 into oxidized environment it can product the gradient films of complex materials. The proportions of Nb2O5 and SiO2 components are varieties in relation of the algorithm of the substrate movement. It may be linear profile as it is shown on Fig.1 and Table 1 – sample 1, obtained where the substrate movement is linear and more complicate profiles (samples 2 and 3) obtained in relation of the algorithm of the substrate movement [2].

It is shown that using of the spectral ellipsometrical metrology methods and metrology device M-2000 makes it possible to improve the technology process of thin films production.


\begin{table}[h]
  \centering
  \begin{tabular}{|c|c|c|c|c|c|}
    \hline
    N & The thickness \(d\), nm. & \(n\) (\(\lambda=632\text{ nm}\)) top & \(n\) (\(\lambda=632\text{ nm}\)) bottom & \(k\) (\(\lambda=632\text{ nm}\)) top & \(k\) (\(\lambda=632\text{ nm}\)) bottom \\
    \hline
    1 & 57.2 ± 0.3 & 1.89 & 1.81 & 0.0033 & 0.0026 \\
    2 & 49.2 ± 0.5 & 1.52 & 2.34 & 0.0012 & 0.0282 \\
    3 & 48.0 ± 0.3 & 1.51 & 2.2 & 0.0003 & 0.0075 \\
    \hline
  \end{tabular}
  \caption{The parameters of the gradient thin films of the samples: 1, 2 and 3.}
\end{table}

Fig. 1. The percentage of SiO2 into complex materials Nb2O5 + SiO2 across thin films thickness of the samples: 1, 2 and 3.