OPTICAL CHARACTERIZATION OF NON-STOICHIOMETRIC SILICON NITRIDE FILMS PREPARED BY MAGNETRON SPUTTERING

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The optical characterization of several samples of non-stoichiometric silicon-nitride films deposited on double-side polished silicon single crystal wafers is performed. The silicon nitride films are prepared by magnetron sputtering. By changing the amount of nitrogen used during the deposition it is possible to prepare silicon nitride films with different stoichiometric ratio. Our main goal is to determine how the optical constants of the silicon nitride films depend on the deposition conditions (e.g. on the nitrogen flow rate). The deposition rate can also be estimated from the determined thicknesses of layers and deposition times.

The optical characterization is based on simultaneous processing of ellipsometric data measured in the spectral range 0.6–6.5 eV for five incidence angles within the range 55–75° and reflectometric data measured in the spectral range 0.7–6.5 eV at near normal angle of incidence.

The dielectric response of the non-stoichiometric silicon nitride is described by a simple three-parametric model of interband transitions. In this model, the imaginary part of the dielectric function is given as

$$\varepsilon_{i}(E) = \frac{N\left(E - E_{g}\right)^{2}(E - E_{h})^{2}}{CE^{2}} \text{ for } E_{g} < E < E_{h} \text{ ,}$$

where the symbols E_g and E_h denote the minimum and maximum energy of interband transitions, the symbol N determines the strength of these transitions. Outside of the interval $E_g<E<E_h$ we define $\varepsilon_i(E)=0$. The normalization constant C is calculated using the sum rule. The real part of the dielectric function is calculated from the imaginary part using the Kramers–Kronig relation.

Since the films are placed on top of double-side polished silicon wafers the depolarization due to the back side reflections must be taken into account in the infrared region, where the silicon wafer is transparent. The possibility of the presence of defects influencing the optical quantities of the silicon nitride film such as the random roughness of the upper boundary, overlayer, slight inhomogeneity (refractive index profile) is also investigated.

As the results achieved the dependencies of the optical constants and dispersion parameters of the characterized non-stoichiometric silicon nitride films on quantities describing the technological conditions such as the nitrogen flow rate are presented. An attempt at interpretation of these results is also made.

Keywords: Ellipsometry; Reflectometry; Silicon nitride films; Optical characterization