A simple polarimetry configuration is used for measuring the thickness of a nonabsorbing thin film on an absorbing substrate from the ratio between the spectral reflectances of perpendicular and parallel-polarized components reflected from the thin-film structure. The spectral reflectance ratio measured at a fixed angle of incidence is fitted to the theoretical one to obtain the thin-film thickness provided that the optical constants of the thin-film structure are known. This procedure is used for measuring different thicknesses of a SiO\textsubscript{2} thin film on a Si substrate. Moreover, an approximate linear relation between the thin-film thickness and a wavelength of the maximum of the reflectance ratio for a specific angle of incidence is revealed when the substrate is weakly absorbing.

### 2. Measurement method
To measure the reflectance ratio $R(\lambda)$, a three-step procedure with a spectrometer can be used [1]:

$$R(\lambda) = \frac{R_p(\lambda) - R_s(\lambda)}{R_p(\lambda) + R_s(\lambda)}$$

(1)

### 3. Theoretical background
The spectral reflectances of perpendicular and parallel-polarized components and the theoretical reflectance ratio $R(\lambda) = R_p(\lambda)/R_s(\lambda)$ of the thin-film structure as well, can be expressed using:

$$R_p(\lambda) = \frac{R_{p,S}(\lambda) + R_{p,m}(\lambda)}{1 + R_{p,S}(\lambda)/R_{p,m}(\lambda)}$$

$$R_s(\lambda) = \frac{R_{s,S}(\lambda) + R_{s,m}(\lambda)}{1 + R_{s,S}(\lambda)/R_{s,m}(\lambda)}$$

(2)

The equation contains the relationship between the thin-film thickness and the wavelengths $\lambda_{max,m}$ of the reflectance ratio spectrum [1]:

$$d = 4(\nu)(\lambda_{max,m})^2 + \frac{1}{\nu^2}$$

(3)

where $\nu$ is an integer.

### 4. Numerical simulations
Using Eq. (2), we constructed the theoretical spectral reflectance ratio $R(\lambda)$ as a function of wavelength for a SiO\textsubscript{2} thin film on a Si substrate (see Fig. 2) and the data taken from [2, 3]. We constructed the approximative function $d = f(\lambda_{max,m})$ derived from Eq. (3), where $\lambda_{max,m}$ is the wavelength of the maximum, which is close to $\lambda_{max,S}$ for a weakly absorbing substrate [1]. This dependence is illustrated in Fig. 4 for three angles of the incidence $\alpha = 30^\circ$, $45^\circ$, and $60^\circ$. According to Fig. 4, it is evident that the functions are linear (the correlation coefficients of the linear fits are 1) and can be expressed as:

$$d = A + B\lambda_{max,m}$$

(4)

where the characteristic parameters $A$ and $B$ are listed in Table 1.

### 5. Experimental results and discussion
The wavelength dependence of the reflectance ratio $R(\lambda)$ was measured for three samples of SiO\textsubscript{2} thin films on a Si substrate (see Fig. 4) by the three-step procedure presented above (angles of the incidence $\alpha = 30^\circ$, $45^\circ$, and $60^\circ$). The thicknesses $d_1$ and $d_2$ of the SiO\textsubscript{2} thin films determined from the maxima and the measured reflectance ratios, respectively, are listed for $\alpha = 45^\circ$ in Table 2. The results agree very well with those obtained by a technique of spectral reflectometry [4]. Moreover, the dashed curves in Fig. 4 (the theoretical reflectance ratios) demonstrate a good agreement between the theory and experiment.

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### References