

Ellipsometric plasmon sensor for adsorbed layers on thin Ag and Au films

V.L.Severynov, I.A.Shaikevich, Y.A.Shybiko

T.Shevchenko Kyiv National University,
6 Acad. Glushkov Ave., 03127 Kyiv, Ukraine

Using Kretschmann's method, important parameters defining the propagation of surface waves (namely, the restored polarization azimuth Ψ and phase difference Δ between *p*- and *s*-components of the electromagnetic wave) versus the light incidence angle Θ for thin Ag and Au films have been investigated. It has been show that at wavelength λ = 620 nm, the ellipsometric sensor on Au film is more sensitive to molecular pollutions than sensor on Ag film.

Используя метод Кречмана, исследованы угловые зависимости поляризационных параметров (азимут Ψ восстановленной линейной поляризации и сдвиг фаз Δ между *p*- и *s*-компонентами поляризации электромагнитной волны) для тонких пленок Ag и Au. Показано, что на длине волны λ = 620 нм эллипсометрический сенсор, изготовленный на пленке золота, является более чувствительным к молекулярным загрязнениям, чем на пленке серебра.

The number of investigations devoted to thin film structures is increasing rapidly during recent years. One of the practically important aplications of thin films is development of ellipsometric sensors being used to solve the problems of ecological monitoring, controlling and automation of technological processes and in scientific investigations. An advantage of optical sensors consists in that those are contact-free (and thus do not distort the measurement results). Abeles [1] was the first who carried out ellipsometric investigation of adsorbed layers on thin Ag films due to surface plasmons excitation. For Ag film of 50 nm thickness, he cleared up the existence of narrow plasmon minimum at the angle of light incidence about 45°.

Using the Kretschmann's method, ellipsometric parameters (namely, the restored polarization azimuth Ψ and phase difference Δ between *p*- and *s*-components of the electromagnetic wave polarization) versus the incidence angle Θ for thin Ag and Au films within thickness range of 1 Å to 700 Å have been calculated. Experiments were performed at fixed wavelength λ = 620 nm and variable angles of light incidence. The large range of the light incidence angle from 0 to 90° and different thickness of films (measured experimentally using the Beattie method [2]) were considered. The Eerie relationships were used [3]. The refractive and absorption indices for Ag and Au were taken from [4].

For both materials, our results have evidenced the existence of narrow plasmon minimum at the angle of incidence of 45° besides of a minimum at the pseudo-Brewsterian angle. The deepest minima were observed for Ag at the film thickness of 23 nm and for Au at that of 56 nm.

The next step was the calculation of tgΨ(Θ) and cosΔ(Θ) for Ag at 23 nm thickness covered by ultrathin dielectric film (the refractive index n_1 = 1.46), of various thickness (from 0.1 to 15 nm) using the bilayer model. Similar calculations were carried out for thin Au film (*d* = 56 nm) covered by the same dielectric material. The data were taken in the Kretschmann configuration.

Fig. 1 shows experimental tgΨ versus Θ for Ag film (*d* = 23 nm) covered with a dielectric of various thickness. Along the or-

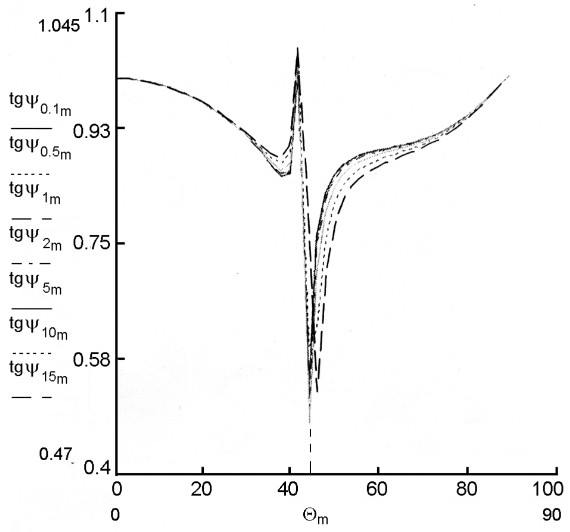

Fig. 1. Tan Ψ versus Θ, the angle of incidence, at fixed wavelength λ = 620 nm for Ag films at fixed thickness d = 23 nm covered with a dielectric of 0.1, 0.5, 1, 2, 5, 10 and 15 nm thickness.

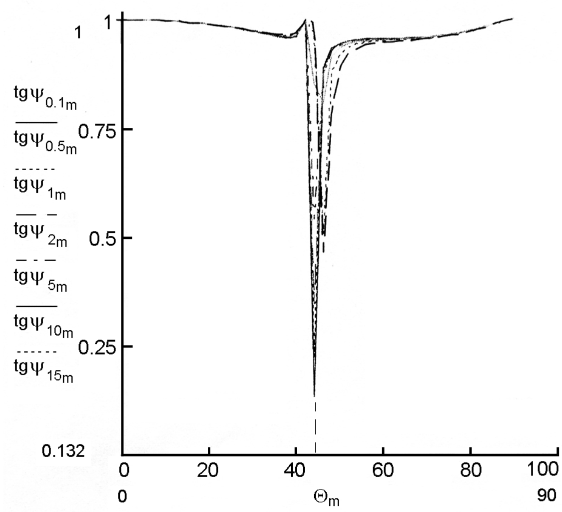

Fig. 2. Tan Ψ versus Θ for Au films (d = 56 nm) corresponding to the same configurations and data as in Fig. 1.

dinate axis (tgΨ), the thickness of dielectric film is indicated in nanometers. According to the results of Fig. 1, the largest sensitivity of tgΨ to the dielectric film thicknesschange is observed in the region of plasmon minimum at the angle of incidence (Θ ~ 45°), and also in area of the pseudo-Brewsterian angle (Θ ~ 35°).

Figure 2 demonstrates tgΨ versus Θ for gold film (d = 56 nm) at the same thickness of adsorbed dielectric films. It is to note that the minimum of tgΨ at the pseudo-Brewsterian angle (around 35°) is not so deep as for silver. This is due to the fact that Au thickness is larger than that of Ag. Therefore, the best sensitivity of tgΨ to the thickness change of the adsorbed dielectric film is observed only at the angle of plasmon minimum which is about 45°.

The relative sensitivity was calculated using the tgΨ change when the thickness of the adsorbed film was changed by 1 Å within 1 to 5 Å range. For a sensor on Ag film base, this value is 0.38 % while for that on Au film, it is 21.4 %. Thus, on wavelength λ = 620 nm, the ellipsometric sensor on Au film is more sensitive to molecular pollutions than that using an Ag film.

References

1. F.Abeles, *Surface Science*, **56**, 237 (1976).
2. A.V.Sokolov, Optical Properties of Metals, NIFML, Moscow (1961) [in Russian].
3. M.Born, E.Wolf, Principles of Optics, Cambridge University, Cambridge (1973).
4. I.H.Weaver, C.Krafka, D.W.Lynch, E.E.Koch, Optical Properties of Metals, v.1. II Int. Report D.E.S.I. F41 Hasilab (1981), v.1, 428p.

Еліпсометричний плазмонний сенсор для адсорбованих шарів на тонких плівках срібла та золота

В.Л.Северинов, І.А.Шайкевич, І.А.Шибіко

З застосуванням метода Кречмана досліджено кутові залежності поляризаційних параметрів (азимут Ψ відновленої лінійної поляризації та зсув Δ фаз між p- та s-компонентами електромагнітної хвилі) для тонких плівок Ag та Au. З цих даних видно, що на довжині хвилі λ = 620 нм еліпсометричний сенсор, виготовлений на плівці золота, має вищу чутливість до молекулярних забруднень, ніж сенсор на плівці срібла.