Optical metrology of an isolated crystalline zinc oxide microsphere on a gold substrate

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1. Introduction

We try to use an efficient and accuracy method to describe optical scattering from an isolated crystalline zinc oxide (ZnO) microsphere on a gold substrate. The calculated three-dimensional (3D) microscopic ellipsometry imaging pictures with nanoscale resolution are present. We calculate the $\Psi$ and $\Delta$ spectra for specular reflections for the specific frequency.

2. General Instructions

For an isolated micro-scale spherical object, we can obtain the local function $u_i(r')$ by solving Lipmann-Schwinger (L-S) equation [1]

$$e^{ik_0r}u_i(r) = \frac{1}{N_i}E_0(r) + \sum_{j=1}^{N_i} \int dr'G(r,r')V_j(r')e^{i(\kappa_r-k_0r)}u_j(r'),$$  \hspace{1cm} (1)

where $r$ is restricted in cell $i$, $G(r,r')$ denotes the dyadic Green’s function for the uniform multilayer background material [1-2], and $E_0(r)$ denotes the unperturbed electric field. $V_j(r)$ describes the perturbation due to replacing the dielectric constant of the background material (denoted by $\varepsilon_b$) by the one for nanoparticle (denoted by $\varepsilon_a$). Under the spherical basis, we can evaluate the near field distribution on the plane $z=0$ (which corresponds to the microscopic image seen in the scatterometry measurements detected at normal direction) according to

$$E(x,y,0) = E_0(x,y,0) + \frac{1}{A_{cell}} \int k_xdk_x \sum_{n} \int_{r}^{2\pi} J_n(k_x\rho)e^{in\phi}G_n,$$  \hspace{1cm} (3)

where

$$G_n = \int \frac{d\phi}{2\pi} e^{-im\phi},$$  \hspace{1cm} (4)

$$\int dz'g_0(0,z')\int d\phi \int \rho'd\rho' e^{-ik_0\rho'}[V_j(r')u_j(r')].$$

Fig. 1 shows the calculated $\Psi$ and $\Delta$ spectra for specular reflections for the specific wavelength 400nm and the incident angle $60^\circ$. The maximum value of angular momentum considered is $l_{max} = 100$. A fine integration mesh was used to ensure convergence. The diameter of ZnO is $5\mu m$ and the focus area considered is $100\mu m^2$.

3. Conclusions

We have applied the Green’s function method based on spherical harmonic functions to study three-dimensional (3D) microscopic ellipsometry imaging pictures with nanoscale resolution. This will be very useful for exploring biological samples.

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References