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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 Ψ and △ spectra for specular reflections for the specific frequency.

2. General Instructions

For an isolated micro-scale spherical object, we can obtain the local function $\mathbf{u}_1(\mathbf{r}')$ by solving Lipmann-Schwinger (L-S) equation [1]

$$e^{i\mathbf{k}_0\cdot\mathbf{R}_i}\mathbf{u}_i(\mathbf{r}_i)=\sqrt{N_u}\mathbf{E}_0(\mathbf{r})+\sum_{j=1}^{N_u}\int d\mathbf{r}'\mathbf{G}(\mathbf{r},\mathbf{r}')\bullet V_j(\mathbf{r}')e^{i\mathbf{k}_0\cdot\mathbf{R}_j}\mathbf{u}_j(\mathbf{r}_j'), \quad (1)$$

where $\mathbf{r}$ is restricted in cell i, $\mathbf{G}(\mathbf{r},\mathbf{r}')$ denotes the dyadic Green's function for the uniform multilayer background material [1-2], and $\mathbf{E}_0(\mathbf{r})$ denotes the unperturbed electric field. $V_j(\mathbf{r})$ denotes

$$V_j(\mathbf{r})=(\varepsilon_a-\varepsilon_b)k_0^2, r<a_j; 0, r>a_j \quad (2)$$

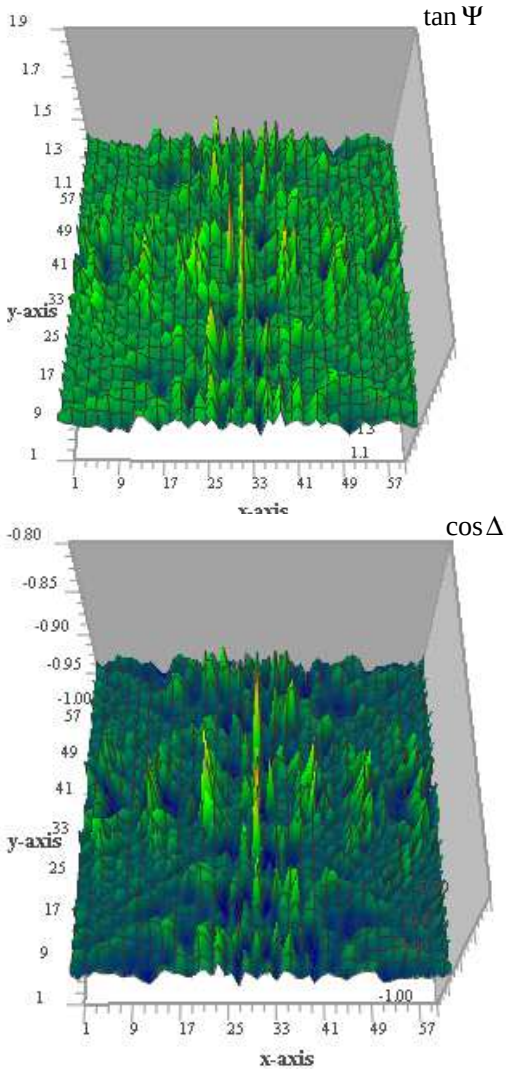
describes the perturbation due to replacing the dielectric constant of the background material (denoted by ε_b) by the one for nanoparticle (denoted by ε_a). Under the spherical basis, we can evaluate the near field distribution on the plane z=0 (which corresponds to the microscopic image seen in the scatterometry measurements detected at normal direction) according to

$$\mathbf{E}(x,y,0)=\mathbf{E}_0(x,y,0)+\frac{1}{A_{cell}}\int k_n dk_n\sum_m i^m J_m(k_n\rho)e^{im\varphi}G_m \quad (3)$$

where

$$G_m=\int\frac{d\tilde{\phi}_n}{(2\pi)^2}e^{-im\tilde{\phi}_n}\int dz'\mathbf{g}_n(0,z')\bullet\int d\phi'\int\rho' d\rho' e^{-i\mathbf{k}_0\cdot\boldsymbol{\rho}'}[V_1(\mathbf{r}')\mathbf{u}_1(\mathbf{r}')]. \quad (4)$$

Fig. 1 shows the calculated Ψ and △ spectra for specular reflections for the specific wavelength 400nm and the incident angle 60°. 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

[1] H. Y. Xie, Y. C. Chang, G. Li and S. H. Hsu, *Opt. Express* **21**, 3091-3102 (2013); ibid, arXiv:1305.6423v1.
[2] Y. C. Chang, G. Li, H. Chu and J. Opsal, *J. Opt Soc. Am. A* **23** 638-645 (2006).

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