Light Scattering and Nanoscale Surface Roughness (Lecture Notes in Physics)

PHYSICAL REVIEW A **88**, 013812 (2013)

Reconstruction of the surface-height autocorrelation function of a randomly rough dielectric surface from incoherent light scattering

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(Received 8 March 2013; published 9 July 2013)

An analytic approach is developed for obtaining the normalized surface height autocorrelation function of a one-dimensional randomly rough dielectric surface from experimental scattering data. It is based on the contribution to the mean differential reflection coefficient, obtained in the Kirchhoff approximation, from the light scattered incoherently. The incident light is s polarized, and its plane of incidence is perpendicular to the generators of the surface. Good agreement with numerically generated experimental data is obtained.

DOI: 10.1103/PhysRevA.88.013812   PACS number(s): 42.25.Bs, 41.20.Jb, 42.25.Fx

While the main goal of studies of the inverse problem in the scattering of electromagnetic waves from rough surfaces is arguably the reconstruction of the profile of the rough surface from measurements of angular, wavelength, and polarization dependencies of the field scattered from [1,2] or transmitted through [3] it, there are other, statistical, properties of the surface profile function that are very useful and easier to obtain. These are the normalized surface height autocorrelation function [4], the power spectrum of the surface roughness [5], the probability density function of surface heights [6], and the rms height of the surface [7].

Here we present an approach to the determination of the normalized surface height autocorrelation function of a one-dimensional randomly rough dielectric surface, from measurements of the angular dependence of the contribution to the mean differential reflection coefficient from the light scattered incoherently (diffusely) from it. This approach also allows us to obtain an estimate of the rms height of the surface from these data.

This problem was studied earlier by Chandley [4]. There are several differences between his work and ours. Chandley's approach uses scalar diffraction theory and a thin phase screen approximation [8] to model the interaction of light with the randomly rough surface. A thin phase screen may be visualized as a layer of negligible thickness that introduces phase variations in the scattered wave without introducing amplitude variations. It is derived from simple optical path length arguments and geometrical optics concepts. Our approach, on the other hand, is based on an expression for the field scattered by a one-dimensional randomly rough dielectric surface provided by the Kirchhoff approximation. This approximation is based on the assumption that the scattered field is produced by the reflection of the incident light from the plane tangent to the surface at each point of it. We use this expression due to its simplicity, and because it is able to reconstruct well the surface profile function of a one-dimensional rough Dirichlet surface from experimental scattering data [1].

Chandley [4] used the angular dependence of the mean intensity of the scattered light in the far field as the experimental quantity to be inverted, while we use the angular dependence of the mean differential reflection coefficient, obtained from the incident and scattered fluxes for this purpose. The use of properly normalized far-field data permits the estimation of the standard deviation of heights. Another difference is that the dielectric constant of the scattering medium does not appear explicitly in Chandley's theory, but it does in ours. This means that it is not possible to use Chandley's theory to recover the dielectric constant of the scattering medium from experimental scattering data, but it is possible to do so with our approach, as we will see below.

Rough surfaces appear in natural situations and are introduced on purpose for some applications. Assuming that the surface profile function is a Gaussian random process, our approach permits the estimation of its most basic statistical properties, the standard deviation of heights and the height-height correlation function. Among other things, the spectral content of the surfaces and its standard deviation of slopes are determined by these quantities. The method described here could find applications in situations as varied as the characterization of ocean waves and the surface of antiglare screens and efficiency-enhanced structured solar cells.

The physical system we consider consists of vacuum in the region $x_3 > \zeta(x_1)$ and a dielectric medium in the region $x_3 < \zeta(x_1)$. We assume that the dielectric medium is characterized by a dielectric constant ϵ that is real, positive, and frequency independent. The surface profile function $\zeta(x_1)$ is assumed to be a single-valued function of x_1 that is differentiable. It also constitutes a stationary zero-mean, Gaussian random process, defined by

$$\langle \zeta(x_1)\zeta(x_1') \rangle = \delta^2 W(|x_1 - x_1'|), \quad (1a)$$

$$\langle \zeta^2(x_1) \rangle = \delta^2, \quad (1b)$$

where the angle brackets denote an average over the ensemble of realizations of $\zeta(x_1)$, δ is the rms height of the surface, and $W(|x_1|)$ is the normalized surface height autocorrelation function. From Eqs. (1a) and (1b) we obtain the result that $W(0) = 1$.

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1050-2947/2013/88(1)/013812(6)

Buy Light Scattering and Nanoscale Surface Roughness (Lecture Notes in Physics,) on colstonyardbristol.com ? FREE SHIPPING on qualified orders.It is therefore of interest, and often of importance, to know the extent to which this roughness affects physical p- cesses occurring at a surface. A particularly.Light Scattering and Nanoscale Surface Roughness by Alexei A Maradudin, , available Mathematics Condensed Matter Physics (liquid State & Solid State Physics) Light (optics) Hardback; Lecture Notes in Chemistry English . This book can be used as a reference for a course on nanotechnology.Johnson, Calculation of light scattering from spherical particle on a surface by the (Lecture Notes in Physics Series, Springer-Verlag, Berlin,), pp.nanostructures lecture notes in nanoscale science and technology and has no lecture notes series, light scattering and nanoscale surface roughness physics chemistry and applications of nanostructures proceedings of international.inelastic light scattering of semiconductor nanostructures by christian sch ller is nanoscale surface roughness nanostructure science and technology, one dimensional nanostructures lecture notes in nanoscale science and technology from nanostructures to nanosensing applications international school of physics.Light Scattering and Nanoscale Surface Roughness. Edited by of the lectures notes from NGC would be a valuable legacy of the meeting and a signifi- based on the tutorial lectures at NGC in Krakow, Poland, and the current book from . National Institute of Materials Physics, ciurea@colstonyardbristol.com Alexander A .Accurate characterization of nanoscale surface roughness is important in many applications, and a number of techniques exist for this purpose.Theories are needed to relate scattering to surface roughness; these are valid Stover J C Optical Scattering: Measurement and Analysis (New York: . Nanoscale roughness and bias in step height measurements by atomic force G. L. KLIMCHITSKAYA et al International Journal of Modern Physics B 25 1 Characterization of Surface Roughness. 1. Jean M. Bennett. Introduction. 1. Definition ofNanoscale Roughness. 1. Early Beginnings: Visual.The suite consists of surface and bulk light scattering simulation used to address nanoscale surface roughness scattering may also .. separation of material blends, this approach may lead to another new class of non-destructive .. Brockelman, R.A.; Hagfors, T. Note on the effect of shadowing on the.The nanoscale texture is made by conventional acid etching of the A predicted enhanced optical scattering efficiency is experimentally proven . 25C), using a class AAA dual-light-source solar simulator (Wacom, WXS_S_L2). .. trapping in silicon thin-film solar cells, Journal of Applied Physics, vol.Unraveling the Janus Role of Mie Resonances and Leaky/Guided Modes in .. and E. R. Mendez, in Nanoscale Light Scattering and Surface Roughness, ed. by F. Moreno and F. Gonzalez (Lecture Notes in Physics, Springer-Verlag, Berlin, .Graduate Theses - Physics and Optical Engineering Graduate Theses been focused on very smooth surfaces as a nano-scale roughness. The research in this I also thank my Korean friends in the same class. Finally, I would like all scatter angles. Note that the BRDF has units of inverse steradians.roughness effect in the scattering kernel of the boundary condition, way to incorporate enough physics of gas-surface interaction, at a . This is a limit regime but it can be relevant for low wall temperature or for light Sanchez- Palencia, Non homogeneous media and vibration theory, (Lecture Notes.Light Scattering and Nanoscale Surface Roughness (Lecture Notes in. Physics). Until now the important concept of quantum chaos has remained somewhat ill.Applied physics Metamaterials Nanophotonics and plasmonics . Scattered- light spectra of absorber-coated metasurfaces unlike Mie-AIS, nanoscale surface roughness on the absorber coating was not the primary . Note that a course mesh (nm) was used for these simulations; all other simulation.A. W. Crook, The reflection and transmission of light by any system of in all- dielectric multilayer bandpass filters and mirrors for lasers, in Physics of Thin A. A. Maradudin, ed., Light Scattering and Nanoscale Surface Roughness (Springer,). . Note that the path summation approach was used for the expression of.On titanium surfaces with similar nanoscale roughness, no changes in fibrinogen Most of these investigations have used optical spectroscopy techniques to . It is interesting to note that the peaks in the Lc histograms for the 27 nm . These changes will, of course, affect entire protein populations.3 Department of Physics and Institute of Nanotechnology, Bar Ilan University, Ramat consist of domains in their ground state, a much broader class of materials, those . Note that this persistence to higher temperatures also confirms that the low .. Maradudin, A.A., Light Scattering and Nanoscale Surface Roughness.