Generation of partially coherent light in rough surface scattering and suppression of the speckle it produces

A. A. Maradudin, T. A. Leskova,[1] and E. R. Méndez[2]

[1] Department of Physics and Astronomy and Institute for Surface and Interface Science, University of California, Irvine, California, 92697, U.S.A.

[2] División de Física Aplicada, Centro de Investigación Científica y de Educación Superior de Ensenada, Km. 107 carretera Tijuana-Ensenada, Ensenada, B.C. 22860, México

In this paper we show how to design a two-dimensional randomly rough surface that, when illuminated at normal incidence by a monochromatic scalar beam with a suitably chosen intensity profile, produces a scattered field with a specified spectral density and a specified spectral degree of coherence in the mean scattering plane. We study the propagation of the scattered field into the far zone, and show that surfaces of this type can be used to transform an incident beam with a specified intensity profile into a scattered beam with a different specified intensity profile.

If a *single* realization of the randomly rough surface generated by our approach is illuminated by a monochromatic scalar beam, the resulting scattered field is speckled. To suppress this speckle in theoretical calculations of some property of the scattered field, such as its intensity, an average of that property over the ensemble of realizations is carried out. In experimental work a single realization of the randomly rough surface is used, and the suppression of this speckle is often achieved by rotating or dithering the sample. We show that the use of a broadband (polychromatic) beam to illuminate a single realization of a two-dimensional randomly rough surface also suppresses the speckle that would occur if a monochromatic beam were used for illumination, without the need for an ensemble average or for moving the surface.

We then show by computer simulations that the speckle contrast of the scattered field produced when a single realization of a one-dimensional randomly rough surface is illuminated by a partially coherent beam can be significantly reduced from the speckle contrast produced when the same realization of the surface is illuminated by a laser beam, by suitably varying the spectral degree of coherence and the spectral density of the partially coherent beam in its source plane.