Mueller Matrices for Like and Cross Polarized Scattering from Irregular Layered Structures – Comparison of Full Wave Solutions with Experiments

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The atomic force (or scanning tunneling) microscope, used to obtain the statistics of a rough surface, together with a scatterometer, used to measure the Mueller matrix, provide the researcher with essential tools to precisely examine different analytical solutions to diffuse scattering by rough stratified structures. Time-harmonic $\exp(j\omega t)$ excitations are used. Thus for dissipative media, the complex refractive index N is in the fourth quadrant.

Measurements were made with a polarimetric optical scatterometer, and the results were compared with calculated values based on the full-wave analysis. A description of the scatterometer which measures all 16 elements of the Mueller matrix (which related the scattered to the incident Stokes vectors), has been published recently. In a preliminary experiment, calculations based on the full-wave approach are compared with scatterometer measurements of the Mueller matrix elements for an opaque gold film on a silicon wafer. These measurements were taken in the specular direction for a broad range of incident angles, and the complex permittivity of gold was determined. Because the skin depth (proportional to the reciprocal of the extinction coefficient, k) was smaller than the thickness of the gold film, multiple reflections in the film were negligible; the results were relatively easy to verify.

A glass sample with a rough surface on one side was made by slicing a microscope slide in two through its thin dimension. Statistics of the rough surface were measured by using an atomic force microscope. Comparisons were made between calculated and measured Mueller matrix elements for scattering in the specular direction.

Physical interpretations of the analytical solutions that account for scattering upon reflection and transmission across rough interfaces are given. The agreement between calculations and measurements suggests that the full wave polarimetric solutions can provide a reliable database for electromagnetic detection of rough surfaces in remote-sensing applications.