**Inverse Scattering and Superresolved Lithography**

Michael A. Fiddy
Center for Optoelectronics and Optical Communications,
University of North Carolina, Charlotte, NC 28223
mafiddy@uncc.edu; 704 687 6057

In the first Born approximation, it is well known that a Fourier transform relation exists between the far field scattering pattern and the relative permittivity fluctuations associated with the scattering object. The first Born approximation requires weak scattering but if this is not the case, a Fourier relation can still be written between the far field and the product of the permittivity distribution with the total field within the scattering volume. This product is sometimes referred to as the secondary source.

For a scatterer of finite volume, the far field pattern is an entire function of exponential type and can be described using a product of factors representing the function's (complex) zeros or roots. An interesting fact is that the asymptotic zero distributions, i.e. at larger scattering angles, are at locations determined by the overall extent of the scatterer rather than its detailed internal structure. Based on this it is possible to construct a function to represent a scattered field which has prescribed asymptotic zero locations and can therefore be the scattered field from an object of well-defined size. Non-asymptotic zero locations determine the internal structure of the scatterer. In some lithography applications it is desirable to generate a scattering pattern that originates from an object or aperture of known size but which exhibits an extremely narrow or superresolved central intensity peak. This is easily achieved by redistributing the zeros of an entire function so that their density is increased thereby generating a narrow feature in one region of the scattering domain, while the absence of zeros leads to spatially broad and high intensity regions elsewhere. The inverse problem, or more precisely the inverse synthesis problem in the first Born approximation, defines the scattering object by inverse Fourier transformation of this superresolved scattered field. The resulting diffractive element necessarily contains high spatial frequency features but not sub-wavelength structures. Conversely, the extended superresolved diffraction pattern could represent the field emerging from a diffracting structure satisfying the first Born approximation and this does include sub-wavelength structures. The consequences of this are discussed.