A method for dynamic parameterized shape reconstruction. Application to scatterometry.

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In order to follow the future nano-manufacturing requirements, extremely high performance has to be reached in metrology techniques. For the manufacturers, one of the major needs is in *dynamic* metrology, the aim being to be capable of real-time process follow-up. Scatterometry has proven its ability to fulfill these requirements: non-destructive, non-invasive and above all, qualified for real-time. In this paper we disclose a pioneering algorithmic solution for *real-time* scatterometry, i.e. a solution for a *dynamic inverse problem*.

In scatterometry, the *direct problem* consists in computing a spectral ellipsometry response to a signal of light scattered by a well-defined periodic nano-structure (parameterized by geometrical metrics like height, width, period, etc.). This *direct* problem is rigorously solvable by an electromagnetic code (*Modal Method by Fourier Expansion* for example). Then, the *inverse* problem is to retrieve the diffracting structure (that is to say, its parameters) being measured the ellipsometry signature.

One of the most widespread techniques for the inverse problem is the *library-search method*: by data-mining techniques, the right diffracting shape is sorted out from a huge set of pre-computed signatures. However, in a dynamic situation where changing data has to be acquired in short time steps, the standard inverse problem is no more efficient. Indeed, for instrumentation reasons, if we want a high frequency in signature acquisition, we have to sacrifice resolution in the spectral domain (i.e. less wavelengths). The approximate inverse problem resolution yields poor precision and accuracy in measurement.

What is presented here is a way to reconstruct a realistic diffracting shape at each time step, considering not only the instantaneous low-resolution signature, but also the variation of the diffracting shape in time.
Connected research is already carried out in living tomography or old movie restoration. The idea is the same: we introduce a certain amount of regularity in the resolution of the inverse problem. As a movie detail cannot disappear and reappear, a diffracting geometry cannot vary irregularly in time.

In this paper, we show a set of algorithms based on time-based Tikhonov regularization for dynamic shape reconstruction and show applications related to semiconductor manufacturing: plasma etch process follow-up.

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