Spectroscopic imaging ellipsometry data inversion: a multivariate approach on k-means and ascendant hierarchical clustering algorithms

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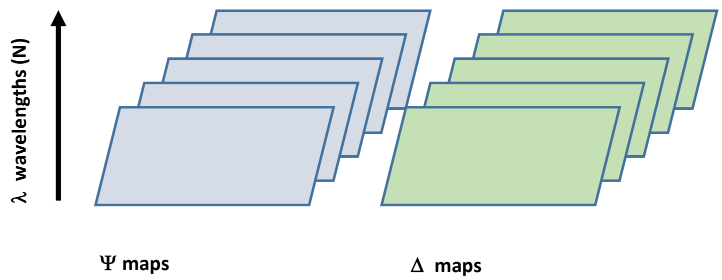
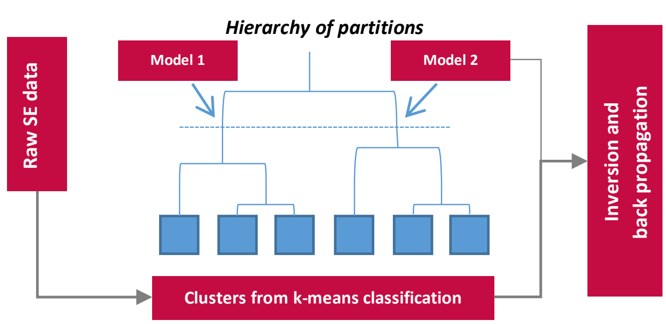
In this paper, we consider two-steps statistical algorithms to identify the pixels of the image from spectroscopic imaging ellipsometry characterizing regions of a sample having a similar optical response. Typically, 256 regions are selected and the ellipsometric equations are numerically solved for each of them. The solution is back-propagated on the initial images to get a thickness or a refractive index map.

Paper

Imaging ellipsometry (IE) is a non-destructive optical analysis technique based on the relative change of polarization of the p- and s- components of the light at the interface between two media characterized by different optical properties. When used in spectroscopic mode (SIE), the technique generates a huge data cube, but contributes to the accuracy of the measurements. As the ellipsometric angles Ψ and Δ have to be interpreted on the basis of an optical model, the inversion of the ellipsometric equations are mandatory to determine the dielectric function of the constitutive layers of an optical stack, as well as their thickness.



Because of the run-time complexity of the algorithm, an inversion of each pixel of the Ψ or Δ map (typically 600x400 pixels) at one wavelength is excluded. We propose a multivariate approach to invert SE data and provide image of the optical parameters, such as the thickness. This approach uses a two-steps classification-scheme based on k-means algorithms and ascendant hierarchical clustering. The classification is applied on a data cube of 2N x L x W pixels, with N the number of wavelengths, L the length and W the width of the mapped region. The k-means algorithms separate the pixels into 256 clusters, and each cluster is associated to a model.



The combination of these two multivariate statistical methods helps in the speed-up of the data inversion, with an appropriate starting guess for the optimization procedure (at least two orders of magnitude) but also in the choice of the local optical model. Examples are given for patterned silicon dioxide samples and the average thickness are close to the expected thickness with Gaussian dispersion.

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