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Selection of a subgrid from a spatial monitoring process

Abstract

Quality of products obtained by slicing surfaces treated by complex process are often controlled by sampling data over a monitoring grid. Examples may be typically in agriculture, textile, steel sheet factories. Strong similarities may be found in semiconductor processes where devices (chipsets) are developed over the surface of a circular-shaped working substrate called wafer by a well-integrated sequence of several steps, called “technological steps”; each step is studied by data acquisition in the development phase. This is usually done by collecting data over an assigned grid (see Fig.1). In the production phase, the number of wafers to be measured/monitored becomes enormous. Data collected in this phase are generally used to check whether both target values are matched and homogeneity exists over the whole production surface. Since the collection of measures is highly time consuming and very expensive it is necessary to ascertain whether the number of sampling points selected in the development phase could be reduced by keeping at an acceptable level the degree of representativeness of the wafer surface and the predictability of the response surface.

Since the sampling points of the reduced grid must be a subset of the original monitoring grid they cannot be simply allocated by some experimental design. However, the number of possible configuration of sampling locations is huge even when the size of the starting grid is moderately large rising a formidable combinatorial problem.

Borgoni et al. (2012) proposed a simulated annealing (SA) algorithm combined with a geostatistical model to select the sub map. The strength of their proposal is that it is fully nonparametric, data driven and naturally selects those regions that are the most effective in predicting the response variable. As a consequence the resulting map may not be regular over the surface and can return maps that are concentrated in subregions.

In this paper we present a different approach that, even without the availability of starting experimental data, selects a sub-grid according to the criterion of spatial optimal coverage of the wafer surface (see also Walvoort, 2010). This approach may also include expert knowledge about those areas where production is less precise because of unavoidable technical reasons and hence may indicate where a higher sampling density must be assured. If sampling measures are available, a validation procedure can be used to select the best sub-map based for instance on the prediction error, by comparing the results obtained using the full and the reduced grid (see Fig.2).
References


Fig. 1: examples of a sampling grid over the wafer

Fig. 2 a) surface and contour of the mean (left) and variance (right) by using the full map; b) surface and contour of the mean (left) and variance (right) by using the sub map.