An approach for operational risk evaluation and its link to control plan

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Study motivation

Semiconductor manufacturing is characterized by complex and highly sensitive processes. Mastering the variability is one of the most important challenges to ensure the best possible quality of products with high yield performances. Statistical Process Control approaches are today widely applied across the various measurement tools and techniques to attain this objective.

In so called high mix fabrication lines, the traditional approach toward process control has come to its limits. The never ending evolution of technologies and product generations, associated to the numerous data sources and techniques available today to ensure process quality and stability have transformed the mastering of process excursions into a complicated and very often overwhelming task.

FMEA is used as the standard approach to adjust control plans in order to reduce global risk (see [1]). Nevertheless, in most cases, it is static and control plans adjustments are then driven by capacity limitations or productivity / cycle time improvement campaigns through non-value added steps reduction.

Whether defined according to FMEA or not, the control plan is translated into MES (Manufacturing Execution System) through sampling rules. These rules are based on process frequency (i.e. measure one every ten), on events (Maintenance just achieved, out-of-control just happened, etc), on lot characteristics (experiment lot, so called rocket, bullet or ambulance lot) and on some exceptions (Run to run regulation loop, mandatory parameter for reporting, etc). Traditional approaches proposed in most of the existing MES are limited and valuable alternatives have been proposed as in [2].

Description of the approach

In this paper, we propose a method for provisional operational risks evaluation which can support decision making concerning the design of control plans. The method consists of evaluating the risk evolution $R^n(i)$ during a considered horizon (H) without any control. Then, an added value (in terms of risks) could be evaluated for any control plan X (see figure 1).

The risk is computed as the multiplication of the probability of a non-desired event (NDE: failure, drift, etc) by the Potential Loss (PL) if this event occurs. The PL is expressed here by the number of lost items (Chip, wafer or lot). We suppose that when a non-desired event happens, it also impacts the quality of subsequent runs, until its next control (the control means measure and correct if not OK). In this case the PL will linearly increase with the number of runs.

Depending on the time the NDE occurs, the evolution of the PL when no control is planned can be represented as in Figure 2. When controls (measures + corrective actions in case of detection) are planned, the Potential Loss is different because:

- If the result of the planned measure is “OK”, there is no need to consider Potential Loss that corresponds to a NDE occurrence previous to the measurement instant (see figure 3).
- If the measure is “not OK”, an action is imminent which will “reinitialize or modify” the Probability of the non desired event and the Potential Loss becomes “Probable Loss” or “Proven Loss”

Assuming that we know the distribution of the probability of NDE along the considered horizon H (see Figure 4), the risk evolution function with a control plan X could be computed as following:

$$R^n(i) = \sum_{j} (i-j+1).PL^X(i).P_{ij}$$

Results and perspectives

Figure 5 presents some experimented examples of risk evolution computation depending on the number of controls and their positions along the considered horizon.

It can be noticed that different control plans have different impacts on risk evolution and different added value compared to the risk evolution without controls. This could be used to define an optimized control plan regarding an objective function related to the added value of a control plan and other manufacturing constraints which will be the aim of our future work.

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References
