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EVALUATION OF SMALL VOLUME PRODUCTION SOLUTIONS IN SEMICONDUCTOR MANUFACTURING: ANALYSIS FROM A COMPLEXITY PERSPECTIVE

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ABSTRACT

In the volatile semiconductor market, leading semiconductor manufacturers aim to keep their competitive advantage by providing better customization. In light of this situation, various technologies are proposed but complexity may also increase. This paper attempts to select the best strategy from the complexity perspective. We borrow the theory of change management and view each new technology as a change to the as-is one. A generic framework to decide the best approach via complexity measurement is proposed. It is applied to a case study with three technologies (shared reticle, compound lot and a combination of both), and for each one we analyze its change impact and increased complexity. This paper delivers both, a guideline on how to build up a complexity index to supplement the cost and benefits analysis, and its practical application to the decision making process to handle small volume production.

1 INTRODUCTION

The semiconductor industry is considered to be one of the most process complex and capital intensive industries. The supply chain in the high-technology semiconductor industry is characterized by non-linear manufacturing processes, fluctuating demands, various products and services, and complex decision making on different levels. It also faces a fierce business environment such as globalization, customization and volatility, which drives leading semiconductor firms to provide more competitive offers in the consumer dominant or B2B market. Due to the changeable nature of products requirements, a flexible and specialized production service is desired (Chien et al. 2011, Chien 2007).

Overall, there is a strong demand for individually low volume chips in sectors such as automotive, aerospace and other industries. Therefore, the semiconductor manufacturer should adapt to a high mix and low-volume production policy in an agile and cost-effective way (Venables 2005). The marketing success of a firm could depend on whether it can seize the opportunities of small volume production.

The low volume requirement also reflects the trend of INDUSTRIE 4.0. The core conception of the INDUSTRIE 4.0 production system is to achieve the profitable manufacturing of products with many options in low volumes. Thus smart factories, which can quickly react to the demand and market needs by providing customized service with low volume will emerge in the future. The future manufacturing is more customer tailored and individualized and towards flexibility and agility (DFKI 2015).

Silicon chips are the foundation of the digital world, and the manufacturing process starts from the raw material - unprocessed wafers. A wafer can have more than thousands dies (chips) – the number depends on the types of products. In recent years, more and more fabs switched to 300mm wafer processing in order to reduce unit production cost. On the one hand, more dies can be produced on one wafer due to the size increasing from 200mm to 300mm diameter; on the other hand, there is a growing

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demand for small orders with low volume chips which do not need mass production. A higher output than demand will result in chips residing at the die bank (the typical intermediate storage point before diversification into different packages) and thus increases cost. This leads to tension between 300mm wafers and low volume production.

Taking a typical semiconductor manufacturer for example, many applications are in the field of consumer electronics, power electronics, automotive electronics and security, where small volume orders have a high demand. It is not unusual in a product portfolio that more than 20% basic types (defined by the photomasks) in Front End have a volume less than 100 wafers per year. As current technologies only produces the same products on a given one wafer, the low volume has to wait until accumulation reaches a vast scale, or go to an over-production. In reality, the small lot size is a major driver for capacity loss in a fab due to overhead times. For example, 10% small volume production means a batch processes less than 6 wafers, which can lead to 5% or more of capacity loss in the Front End.

To better manage the Overall Equipment Effectiveness (OEE) loss, it is necessary to investigate new technologies which can satisfy small volume demand while still keeping efficiency. Therefore, practitioners are keen to look for agile production at low cost. Several technologies for low volume combining multiple products and processes are introduced in the later part of the paper.

The low-volume production with new solutions is a win-win strategy for both manufactures and customers. It brings significant benefits to the manufacturing: enhancing productivity by increasing the capacity utilization; reducing the lead time for small volume products and reacting rapidly to the ramp-up and ramp-down situations; optimizing manufacturing with low-cost. And it will massively contribute to the “green supply chain” by reducing energy and water consumption, as well as CO2 emissions. Customers will be satisfied with a flexible ordering and replenishment strategy and can get faster supply at almost no extra cost. In a nutshell, it gives a direction to improve the current supply chain in the fabs and bring a chance for new business.

The evaluation of new technologies can be addressed from different perspectives: factory integration, engineering, IT, supply chain, etc. In this paper we aim to assess them from the supply chain complexity point of view. It is true that new technologies have great potential benefits, but we should be aware that numerous complexity might be generated from them, which is usually even much higher than what we expected. For example, customization and diversification offers more tailored services, correspondingly more effort is needed in the design and implementation phase, and complexity rising cannot be avoided. Could the increased complexity offset the benefits of these new technologies? We would like to answer this question in a systematic way and thus develop complexity indicators to support decision making.

The rest of this paper is organized as follows. Section 2 describes the decision support framework on the change and complexity evaluation. Section 3 starts with a case study on low volume production and discusses three possible technologies. Then the evaluation framework can be applied to select the best solution and results of complexity measurement on three drivers for each scenario are presented in Section 4. Finally, Section 5 summarizes our findings and concludes the paper.

2 AN OVERVIEW OF COMPLEXITY EVALUATION FRAMEWORK

To evaluate the complexity of new technologies, a generic framework with a step-by-step guide is recommended to be set up. We first bring the philosophy of change into our analysis. In general, the emerging technology can be broadly defined as a change to the current solution. Therefore, the analysis of new solutions can be transformed to the research question of changes. We can thus evaluate the complexities within the scope of changes.

The change process from as-is to a new technology is not that simple, gaps exist between the initial design and final implementation stage. Assume the as-is system has state S, in order to switch to the new system with state S', a change function needs to be implemented. To clearly state the change method, we name the change function as the change execution, and the system state from $S \rightarrow S'$ is the change impact.

Complexities are generated from both changes, and we must consider all of them in order to have a comprehensive evaluation (Sun et al. 2016).

Complexity drivers in supply chain can be classified into three categories: product (data object), process and organization (Sun et al. 2015a). A change may cover all drivers. For example, when a technology changes, product data model might be the change target; additional processes would be added in the execution phase; organizational structure and personnel may be affected, etc.

Our approach can be generalized as three steps: compare with the as-is solution; formalize and evaluate the change; measure the increased complexity. The details of each step are explained as below and also illustrated as a flow chart in Figure 1.

1. Compare the difference between new and as-is solution. The first step is to understand the characteristics of various technologies. It is worth pointing out that the comparison does not have to go through all details of the whole system, but mainly focuses on the differentiation, which are documented as the change specification. A check list with structured information, e.g., added processes, affected data models, is the expected output.
2. Formalize the change and evaluate its complexity. The execution changes can be easily identified from the specification acquired in step 1. It can be decomposed into a series of atomic changes and described as a group of processes. The detection of change impact is more complicated, we need to set the investigation scope first and then identify which complexity drivers are affected. Each aspect needs to be evaluated and their interactions should be considered as well. More details are available in Sun et al. (2016).
3. Measure the increased complexity using a set of indicators. The complexity of affected drivers can be calculated separately using the metrics proposed in Sun et al. (2015b). Since the final goal of this approach should assist the managers to select the best solution, the indicators should include the potential benefits of applying the new technology, the cost of change implementation and the cost of increased complexity.

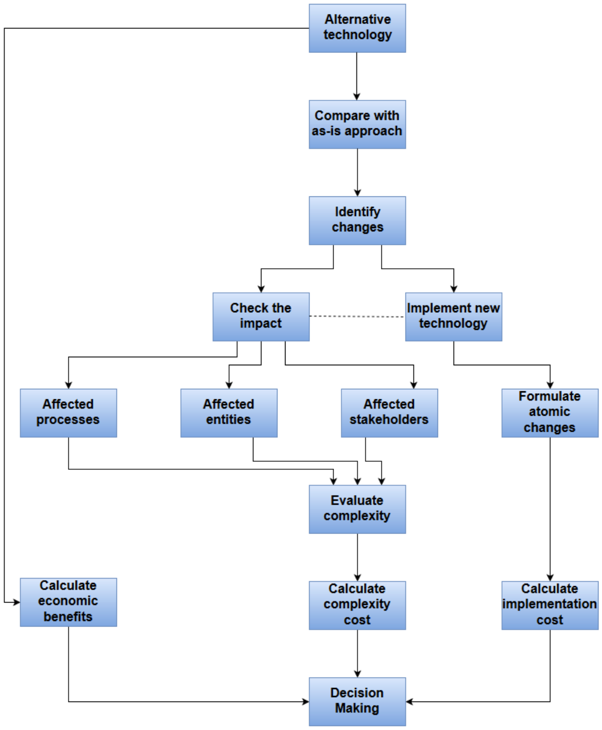

Figure 1: Framework of complexity evaluation on new technologies or approaches.

3 CASE STUDY

We chose several popular low volume manufacturing technologies and develop a case study for complexity and change analysis. For each solution, we briefly present its background and summarize its technical details. The difference with the as-is solution is highlighted and the implementation difficulties are also mentioned, which will be used as an input for the deep analysis in Section 4.

3.1 Terminology

Some technical terms with easy-to-understand definitions are given in Stubbe (Stubbe 2009):

Definition 1 Wafer is a thin, round disk of silicon which is used as the base material in the manufacturing of semiconductor devices.

Definition 2 A product specifies the integrated circuit that is manufactured. A wafer usually has thousands of identical product units which are manufactured simultaneously side to side on it.

Definition 3 A lot refers to a set of wafers that traverse a route together.

Definition 4 AMHS is automatic material handling system. One AMHS can handle multiple FOUPs.

Definition 5 FOUP stands for front opening unified pod. FOUP is a container and used as the wafer carrier to transport lots in a wafer fab. They are needed for the AMHS.

Definition 6 A route describes the process flow that a lot takes. A work route represents a sequence of process steps in manufacturing (mainly at wafer fab).

Definition 7 A tool contains a pattern image that needs to be stepped and repeated in order to expose the entire wafer (EEsemi 2016). A set of reticles (up to 35) is needed to produce a wafer. In this paper we call the reticle set “reticle” for simplicity.

3.2 Background of Available Technologies

Various industrial solutions have been developed regarding the low volume topic. In this paper we highlight two proposals to achieve small volumes: one direction is to have multiple products fabricated on a single wafer, and the other one is to reduce the number of wafers for each lot.

Shared reticle (SR) is one of the solutions for the first direction. Reticle cost is one of the main levers of manufacturing costs. For the as-is manufacturing processes with only mono reticles (MR), if two products (A and B) are desired, two reticles for each A and B are needed to print on individual wafers. With the SR idea both A and B can be produced on one same wafer, hence the two single reticles can be replaced by one shared reticle and cost would be reduced significantly due to the high price of a reticle. The concept is shown in Figure 2. Since multiple products can share one reticle, small volume can thus be achieved; manufacturing costs will decrease substantially because of the reduction of reticle costs.

The SR idea is very attractive from the developer’s point of view, however, if the manufacturing phase does not change accordingly, half of the wafer would be scrapped, since the settings of machines (e.g., testing machine) are only designed for the single product processing on the wafer. So the consequence is each wafer can merely produce either product A or B. For this case the redesign of future manufacturing process with shared reticle is proposed, that it can be used to produce both product A and B on the same wafer without any scrapping. Therefore the affected processes and machines need to be adjusted, which is the most difficult part in the implementation. Some preliminary analysis has been done on the SR scenario (Sun et al. 2015a).

The second direction prefers to have a small-size lot with less wafers. Usually a full lot has 25 wafers which are processed as a group. The small-size lot processing decreases the OEE because it has an inadequate utilization of facilities. To improve the OEE, an idea is to increase the number of lots in a FOUP. That means, a FOUP can have more than one lot; each lot has flexible size and can be processed at selected area of wafers with an individual recipe (own parameters). This solution is called compound lot functionality and is depicted in Figure 3. A compound lot combines different products that share the same work route in one FOUP with 25 or less wafers. It brings challenges to lot traceability and process control on wafers.

The standard concept for 200 mm fab with manufacturing box only contains one lot of only one product, therefore, compound lot (CL) is a concept which is aimed at using 300mm wafers in the manufacture of power semiconductors on thin wafer basis. It is likely to be a standard feature of 300 mm wafer fabs in the near future.

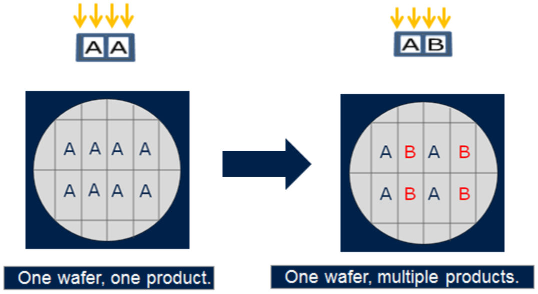

Figure 2: Mono reticle vs. shared reticle.

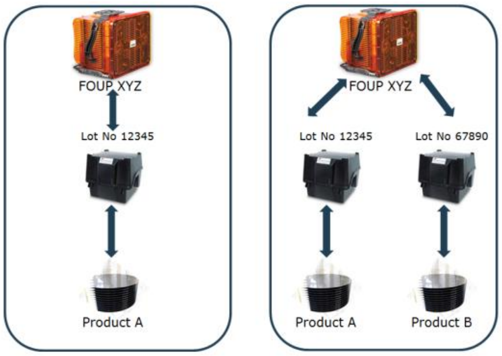

Figure 3: Mono lot vs. compound lot.

It is also possible to combine both SR and CL solutions as an integrated one (SR+CL) for even higher flexibility and more products within one lot, which is much more efficient for multiple products manufacturing.

In total four technologies are introduced in this section: MR (as-is solution), SR, CL and SR+CL. The SR and CL related solutions could remove the obstacle of low volume that hinders fabs in switching to 300mm without losing OEE. Customer requirements can be better fulfilled and cost will be saved.

4 RESULTS ANALYSIS

We continue to analyze above four technologies following the framework proposed in Section 2.

Spreading a new technology within an organization is a big program. As it is a large industrial project with many departments engaged, normally there is a pre-study project to evaluate the effort of realization, potential costs and benefits, etc. However, these preliminary results are limited to certain areas and there are some gaps between the analysis and our expectation. Nevertheless it still affords us values that merit attention. We would like to supplement the analysis from a complexity aspect and provide a more comprehensive evaluation.

According to the evaluation framework, the comparison part has been done in Section 3, then we can concentrate on the change evaluation and complexity measurement parts. It includes several modules: identify the change, assess the main complexity drivers with data objects, process and stakeholders, measure the complexity, and evaluate costs and benefits.

4.1 Identify the Change Execution and Impact

As we mentioned before, the change analysis includes both implementation and impact evaluation. Previous work has done a lot on the former part while not explored deeply on the later one.

In practice, the scope of change management includes: develop the concept of change, list the change specifications, adapt IT and basic data systems, determine the input requirement for machines, etc. Regarding the resources, such as, to set up a cross function team, and to estimate the effort for the project is also prepared at the beginning stage. All of these activities belong to the change realization or implementation. Since most of them have been covered by the project set-up and will be executed by responsible roles, our interest only focuses on the immature part - change impact. Some deficiencies of existing impact analysis are highlighted as below:

- Only consider the direct and explicit impact. For instance, it only points out the additional manufacturing processes, but overlooks the consequences caused by them, such as the increasing workload for the dedicated people, more effort to maintain the new processes, etc. The indirect impact and the afflicted or derived complexities have not gained sufficient attention.
- Only focus on the abstract level. The detection of affected parts does not follow any methodologies but more likely to rely on gut feeling. Evaluation is more from qualitative aspect instead of quantitative methods.
- Sometimes the concept of execution and impact are mixed. To clarify the ambiguity on this point, we can distinguish them by several criteria: the time phase, the frequency, etc. Whether it occurs when the change is being executed, or the state is altered only after completing the change; or whether it is the one-time execution, or it has to be maintained in a regular term.

Our approach aims to overcome these inadequacies in a more comprehensive, detailed and structured way. We investigate potential influenced parts from the data model, process and organization aspects and propose relevant indicators for each.

The impact analysis starts with the state change of a system, however, it is an exhausting task to describe all details including whole manufacturing processes, data models, relationships, etc. So we decide to do the variety analysis only and keep the workload to an acceptable level.

4.2 Entity-Relationship Model

All solutions towards small volume are about producing specific amount of products for the customer. We therefore explore the relationships among products, customers and manufacturing. An Entity-Relationship (ER) Model for general cases is extracted from the requirements and specifications obtained from Section 3. Figure 4 sketches its structure on the level of supply chain network following the regulations of UML diagrams. Some key entities are taken from the reference model in the semiconductor supply chain proposed by Ehm et al. (2011).

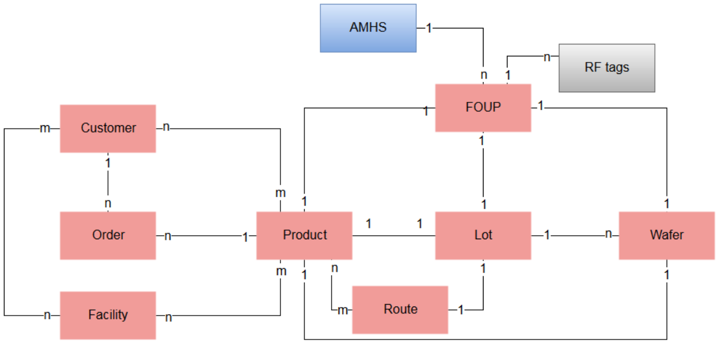

Figure 4: Key entities in the low volume production technologies.

It is worth mentioning that, not all entities in the ER model of Figure 4 will be affected when the technology changes, we are only interested in discrepancies of entities and relationships influenced by various solutions. Therefore the corresponding ER model is simplified for each scenario and only the core part related to changes is kept. The contrast models for all scenarios are shown in Figure 5. It is seen that the entities and data type are kept the same for all cases; only the cardinalities of relationships vary, the distinction of which is highlighted in the diagrams.

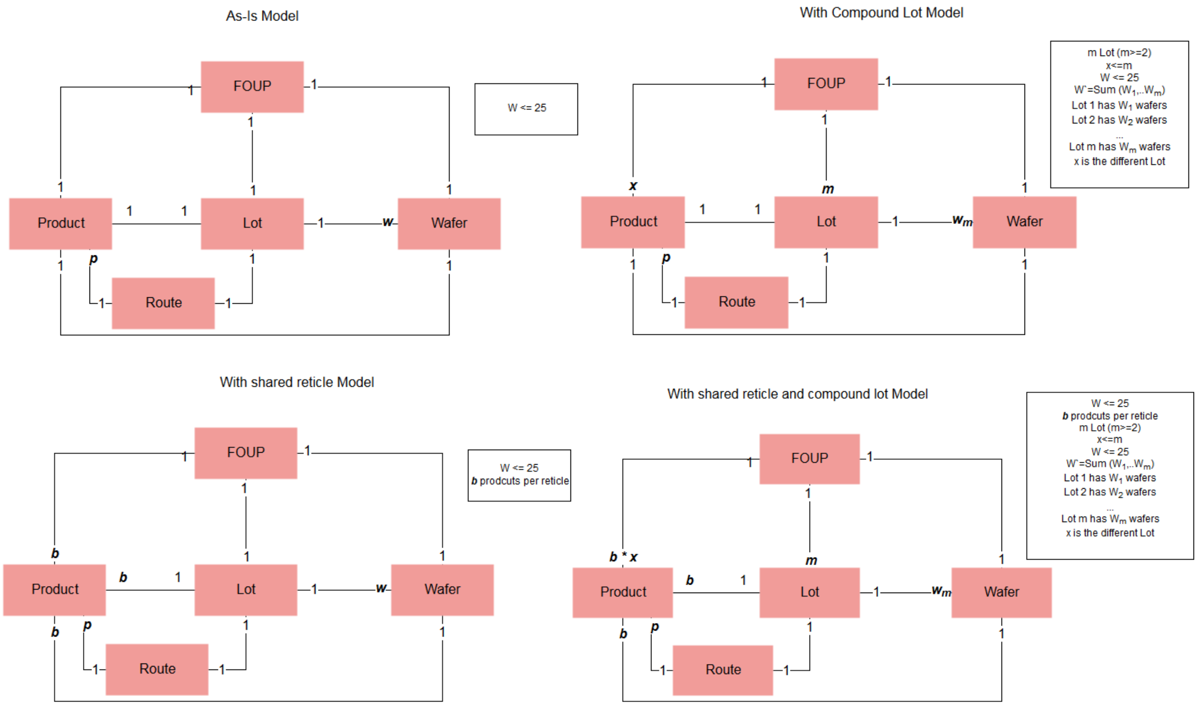

Figure 5: Key ER models for four scenarios.

The main features related to the data model of new technologies are reflected in Figures 4 and 5, and the data is highly integrated, so our analysis can stay on this level and does not need to go to lower ones. We have found that the *product* entity is the key to the whole data model; the *lot* and *wafer* are also important to the structure. In other words, the complicated parts are concentrated on the part of product, lot and wafer. Therefore, we assign the weight value for each object in all scenarios based on its cardinality in Table 1.

Table 1: The complexity weights of key objects for each scenario (b is the product number per reticle, m is the number of small lots within a compound lot, x is the number of small lots with different products).

	MR	SR	CL	SR+CL
Wafer	1	b	x	x
Lot	1	1	m	m
Product	1	b	x	$b{\cdot}x$

The values of variables b, x, m are set based on a specific situation.

4.3 Process Levels

Various processes are involved in the technology change and we refer to a framework to describe them. On the top three levels, we follow the definition of the supply chain operations reference (SCOR) model, which is the most widely accepted framework developed by the Supply Chain Council for standardization in supply chain management (SCC 2012). SCOR has 6 Level-1 processes, 21 Level-2 processes and spans more than 200 Level-3 processes. Level 4 and below processes are specified for individual companies and not provided by the SCOR Model. We compare the SCOR processes thoroughly and achieve the list of possible affected processes for each scenario up to level 3 in Table 2.

However, it is impossible to differentiate these three scenarios only from the top three levels – they have the same processes affected. For example, from the definition, all of them have "*Make*" (Level-

1),"*Make-to-Stock*" (Level-2) and "*Schedule Production Activities*" (Level-3) changed. It is too general to distinguish various technologies on the abstract levels.

Table 2: The maximum number of affected processes on top 3 levels for three scenarios.

	SR	CL	SR+CL	Total process
Level 1	5	5	5	6
Level 2	23	23	23	30
Level 3	82	82	82	201

To tackle this problem, the analysis has to be expanded to the lower level processes. The details uncovered by SCOR can be found in the Architecture of Integrated Information Systems (ARIS) and other supporting documents. Based on the process pool, the major affected processes on low levels for each scenario can be identified. Considering there are at least hundreds of processes on level-4 and more than one thousand on level-5 and below, we decide to combine the key affected processes on low levels at one level only and confine the analysis to level-4 for a low degree of complexity. The results can be divided into two groups: one under the category of *Make*, *Plan*, *Deliver* and *Return* (Level-1), and the other one related to the *Enable* (Level-1) and its sub-processes. Tables 3 and 4 display the numbers of possible affected processes of two groups respectively.

We are aware that the variety of processes appears on Level-4. In the group of *Make/Plan/ Deliver/Return*, a majority of processes are commonly affected in all scenarios, while some of them are only changed by certain technology. Some typical affected processes are listed here. For example, both SR and CL share the same affected process "*Regular Technology Monitoring*" in the *Front End* process under "*Make*", but for another process "*Optical Control*" it is only affected in the SR case, while for the "*Wafer Sorting*" related processes they are heavily involved in the CL case but not much in the SR case. And for the SR+CL scenario, all changed processes in both SR and CL solutions should be considered.

This is similar to the "*Enable*" process family. For example, the process on "*Manage Business Rules for Plan Processes*" are influenced in all scenarios, while for the "*Match Skills/Resources*" (Level-3), it varies according to circumstances. For the SR+CL scenario, in the extreme situation it has to double processes, one for SR and one for CL, like all its sub-processes under "*Manage Data*" (Level-3).

Table 3: The number of maximum affected processes (Make/Plan/ Deliver/Return).

M/P/D/R	SR	CL	SR+CL	Shared processes
Level 2	15	15	15	15
Level 3	55	55	55	55
Level 4	97	115	124	88

Table 4: The number of maximum affected processes (Enable).

Enable	SR	CL	SR+CL	Shared processes
Level 2	8	8	8	8
Level 3	27	27	27	27
Level 4	54	54	72	36

It is noted that most of the variety exists in the detailed level (Level-4), where our investigation area is. Whether we can choose the right level of the process analysis decides the quality of analysis.

The results show that *Enable* has high weight on the added complexity, although it was not highlighted in the previous analysis. It is reasonable for such a significant impact on the overall process complexity, because its concept is centered on the human resources, master data, quality control and risk management, which are the key elements influencing complexity and determine the change quality.

The manufacturing process change has always been addressed as the primary complexity source, however, even considering all affected steps including *wafer sorting*, *cleaning*, *lithography*, *implant*, *resist removal* and *anneal*, it is still a small part of changed processes. Other processes such *as supply chain planning*, *delivery* and *traceability* also have a high influence on the complexity.

It is worth pointing out that the framework of SCOR and ARIS only gives a guide for the process checking, some details on process change especially new steps added might not be found explicitly in existing models, which require us to discover them more carefully.

4.4 Stakeholders Analysis

This part is likely to be omitted or only stays on the superficial discussion level. The existing focal point of industry is usually more about the headcount or availability of human resources, however, we believe the research on the role of humans should not be limited to this, their behaviors, motivation, and other factors which determine the performance of the supply chain should also be considered.

A goal-oriented analysis is our first attempt on this direction. We employ the *i-Star* (*i**) method to evaluate how the goals are satisfied by certain behaviors (Yu et al. 2011). Two models can be obtained: the Strategic Dependency model to highlight various actors and relationships; and the Strategic Rationale model to explore how the goals can be realized through activities. This qualitative approach helps understand the intertwined relationships among actors and their goals.

We thus identify the stakeholders in each scenario and then check whether their actions towards each new technology would be beneficial or harmful to their individual goals. A list of key roles involved in these three scenarios and their attitudes are given in Table 5.

Table 5: A list of key stakeholders and their attitudes for each scenario (N denotes neutral, "+" denotes positive , "-" denotes negative, N/A means the role is missing for this scenario).

	SR	CL	SR+CL
Facilitator	+	+	+
Steering committee	N	N	N
Module head	N	N	N
Capacity planner	+	+	+
Development engineer	+	N/A	+
Head of lithographer	N	N	N
Process engineer	N/A	-	-
Line controller	-	-	-
Test engineer	-	-	-
Operators (lithographer)	-	-	-
Operators (optical control)	-	N/A	-
Operators (wafer sort)	N/A	-	-
IT Master Data team	N/A	-	-
IT Factory integration	N/A	+	+
Quality control team	-	+	N

We can divide the stakeholders into three groups according to their attitudes towards the new technologies: the positive one including the development team who is driven by better design for improving capacity utilization and efficiency, while the negative one is mostly dominated by workers in the factories, who are less motivated to spend more effort or implement the unfamiliar tasks, and the management is neutral before knowing the evaluation results. This analysis result is realistic and practical.

It is noticed that the CL case has more actors than the SR case. One reason is that its change occurs on the lot level, which requires more involvement from a cross-functional team.

4.5 Complexity Measurement

A theoretical approach to measure system complexity is proposed in a previous paper (Sun et al. 2015b). It highlights the influencing factors for complexity including both environmental and internal ones. In this case, all scenarios are under the same environmental settings, therefore we only focus on the internal indicators and choose two of them as a starting point: components and commitment to the intention.

Using the above analysis on data objects, processes and stakeholders, we can calculate the increased complexity for each scenario. The results strongly depend on the variable values of the product number per reticle (*b*), the number of lots in FOUP (*m*) and the different types of lots (*x*). Different values may lead to reverse results.

Figure 6 shows normalized results of two indexes on the simplest example. The complexity size is calculated by the amount of increased components. It is obvious that the SR+CL scenario has more stakeholders and processes changed; and for the objects, the size on the top level is not changed for all scenarios. The commitment means how good the drivers could support to achieve the small volume and cost saving. The calculation of stakeholders follows this way: it counts the percentage of roles who are not against the new technologies. We assume the goal satisfaction on the process aspect is equal for all scenarios if no exception happens. For the data object, it is clear that the SR+CL case has the most efficient way to meet the small volume production. The analysis illustrates the tradeoff between the increased complexity and overall efficiency.

This gives us a hint, although the SR+CL has the largest complexity size of all technologies, it can satisfy the goal the best, which can offset the increased complexity. For the single SR and CL technologies, their complexity is highly correlated to the values of the variables.

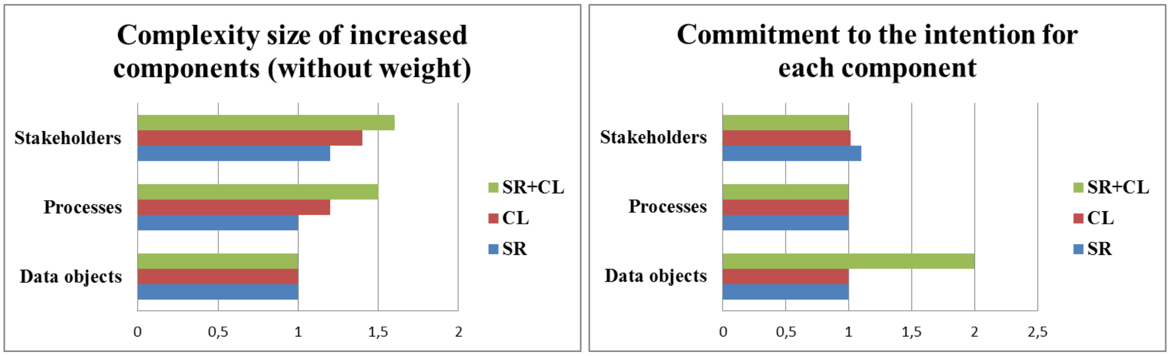

Figure 6: Complexity evaluation on various aspects for three scenarios (assume *b*=2, *x*=2, *m*=2).

A complexity index group with more indicators is planned in the next stage. For example, the complexity of components with weight values should be considered.

4.6 Decision Making

Existing cost and benefits analysis evaluation adopted for technology evaluation is incomplete because many projects practitioners mainly consider the cost of implementation while often neglecting the complexity (impact) caused by implicit change. We therefore add a complexity related indictor, which can be transformed into a monetary value in the end. A comprehensive evaluation for decision making should include these indicators as below:

- Cost of change implementation
- Cost of complexity maintenance
- Benefits of business (Business Impact Analysis)

The cost of change realization can be roughly estimated by companies. Some anonymous data from a typical semiconductor manufacturer reports that the approximate cost of SR and CL is between \$0.5M-\$1.5M for one product. The benefits of business can also be calculated, which relies on the number of affected products, for example, assuming 10% of products are affected, the economic benefits can be up to \$10M for a fab per year. The cost to maintain the increased complexity should also be considered, which consists of the additional resources consumption (processes, machines, operators, etc.) and maintenance costs. In the above example the cost of the increased complexity is less than the benefit from a certain variety of products onwards.

5 CONCLUSIONS AND FUTURE RESEARCH

In this paper, we design a case study with three small volume technologies and attempt to select the best one by following an evaluation framework on complexity and change management. For each technology we compare it with the as-is approach and calculate its increased complexity through a set of complexity indicators addressing various aspects including data objects, process and stakeholders.

Some interesting findings are highlighted here:

- Impact evaluation should choose the right level for analysis. If it is too abstract the changes cannot be identified; if it is too detailed the key information might be missed.
- The change impact on process can be propagated to a large scope than expected. A majority of processes can be affected when a new technology emerges. And it also reminds us to take seriously the key enablers such as IT, quality control, etc., which contribute very high impact on the complexity measurement.
- The combined solution of shared reticle and compound lot is assumed to be the most efficient technology, as the benefits of multiple products can outweigh the increased complexity. Although the economic sweet spot is not completely available yet the proposed approach seems feasible and convinces us in this direction.

In the next step, more indicators can be supplemented to the complexity index group based on the metrics proposed by Sun et al. (2015b). Then we can verify our approach on various products and business scenarios. Furthermore, we would like to extend this approach to other complexity related projects and thus support decision making- by evaluating whether the increased complexity adds value.

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