Prioritizing 5S Activities by Kano Model
For a Semiconductor Wafer Fabrication
Chuan-Yung Chen and Yung-Chia Chang
Department of Industrial Engineering and Management
National Chiao Tung University
1001 Da Hsueh Road, Hsinchu
TAIWAN, R.O.C.
marketer.iem96g@g2.nctu.edu.tw, yungchiachang@mail.nctu.edu.tw

Abstract: Semiconductor wafer fabrication (FAB) is recognized as one of the most complex manufacturing systems. Due to its capital-intensive machines and facilities, a newly built FAB is expected to operate as early as possible. However, a FAB has to pass various audits from its customers before officially operate. 5S audit is one of them. 5S practice is a famous yet fundamental managerial tool for FAB operation. When building a state-of-the-art 300 mm/130 nm FAB, it is common to find hundreds of action items to complete to comply with customers’ expectations toward 5S practice. Moreover, 5S audit on a modern FAB is no longer solely based on checklist. Meeting customers (auditors) expectations become a key factor to pass a 5S audit. Therefore, FAB managers are facing challenges to allocate their resource under time and budget constraints to meet customers’ expectations toward 5S, especially at the ramp-up stage of a new FAB. This study proposes an application of Kano model and CS-coefficient to effectively prioritize action items of 5S practice for a FAB to assist managers allocating the limited resources to the places that are valued most by their customers. A real case drawn from a 300mm semiconductor wafer FAB in Taiwan is analyzed to demonstrate the effectiveness of this approach.

Key-Words: 5S practice; Kano model; Attractive quality, CS-coefficient; Semiconductor fabrication

1 Introduction
Semiconductor wafer manufacturing is widely acknowledged to be among the most complex systems from production planning to shop flow control (Kim et al. 2001). It is recognized that building a 300 mm/130 nm modern FAB would cost as much as billions of US dollars. Not only do its customers cover worldwide but also their perspectives to scene management diversely. Customers frequently audit shop floor to ensure their products are made with high quality. Furthermore, environment, safety and health (ESH) issues for a FAB gradually arouse attentions owing to its potential high pollution and risks. 5S practice, generally speaking as housekeeping, is a famous yet fundamental managerial tool for FAB operation to be certified by ISO 14001 and by OHSAS 18001. Employees are usually educated to perform 5S practice as an integral part of daily job in workplace [1, 2].

5S practice is proposed as a philosophy or way and as a technique or tool by Osada [3] and by Hirano[4], respectively, which is applied to establish and maintain quality environment in an organization. Ho [5, 6] reported that 5S practice is a baseline of TQM and leads to business excellence. The name, 5S, stands for five Japanese words: Seiri, Seiton, Seiso, Seiketsu and Shitsuke [3]. Their meanings and typical examples are shown in Table 1.

<table>
<thead>
<tr>
<th>Japanese</th>
<th>Meaning</th>
<th>Typical Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seiri</td>
<td>Organization</td>
<td>Throw away/return things not needed</td>
</tr>
<tr>
<td>Seiton</td>
<td>Neatness</td>
<td>Clearly designate name &amp; place for everything</td>
</tr>
<tr>
<td>Seiso</td>
<td>Cleaning</td>
<td>Assign individual cleaning responsibility</td>
</tr>
<tr>
<td>Seiketsu</td>
<td>Standardization</td>
<td>Keep transparency</td>
</tr>
<tr>
<td>Shitsuke</td>
<td>Discipline</td>
<td>Keep selfcheck with discipline</td>
</tr>
</tbody>
</table>

5S practice is not easy to cope up with. Hundreds of 5S tasks listed in a “to-do” plan that must be engaged by employees’ involvement. It covers too many action items to identify and to prioritize what should be done first to meet customers’ expectations as a result of practical difficulty. Furthermore, the “feeling” to the scene
management may vary from customers to customers due to their different perspectives. 5S practice has been regarded as a conceptual, linguistic and subjective perspective that has never been quantified and prioritized. It should be addressed with a systematic way in a practical manner. The difficulty to manage 5S practice for FAB managers is how to organize and prioritize these trivial matters into feasible solid actions since all 5S action items are treated as equally important and difficult to be linguistically explicit. From the viewpoint of customers, all 5S practice must all be done immediately and simultaneously without excuses.

However, it is not practically feasible for a large-scale semiconductor FAB, especially during a ramp-up stage under resource constraints. Traditionally, 5S practice is implemented based on an audit checklist and the gleaned action items are treated equally important. While resources are limited, the 5S action items should be managed efficiently and effectively. Hence, it is critical to identify important 5S action items to comply with customers’ audit standards in a feasible manner under resource constraints.

2. Kano Model

2.1 Model Description

Satisfaction drivers have long been discussed for decades. One of significant theories is Kano model that offers some insights into the product or service attributes perceived to be differentiated to customers. Kano model is developed by Noriaki Kano in the 80s [7]. This paper adopts Kano model to solve trade-off problem by prioritizing 5S practice. Kano model builds a bridge to better understand the relationship between performance criteria and customer satisfaction, and to resolve trade-off dilemma in multiple-criteria optimization by identifying the key criteria in customer satisfaction [8]. Using Kano model to prioritize 5S action items is straightforward yet effective to cater customers’ satisfaction. Without doing so, 5S practice shall be endlessly resource-consuming. Kano model focuses on differentiating product or service features as key drivers [9], as opposed to focusing initially on customer needs that contradicts traditional thinking in quality [10]. Kano model has been applied in various products and services to explore customers’ satisfactions [11-18]. It is a customer-driven tool to learn how to sustain customers’ satisfaction and to allocate resources for maximizing customers’ satisfaction under resource constraint [19, 20].

Above all, Kano model can better explore customers’ expectations so that further actions can be taken to improve customers’ satisfaction. Fig. 1 illustrates a comprehensive form of Kano’s two-dimensional quality model.

The different quality attributes described in Kano model are briefly explained as below [7].

1. **Must-be quality (M)**: These attributes are taken for granted when fulfilled but result in dissatisfaction when not fulfilled. Since customers expect that this attribute is viewed as basic and natural, it is unlikely that they are going to tell the company about them when asked about quality attributes. The level of satisfaction to customers will at most be equal to their expectation.

2. **One-dimensional quality (O)**: These attributes result in satisfaction when fulfilled and dissatisfaction when not fulfilled. It is a proportional linearity; i.e. the more the attributes the service renders the more quality the customer perceives.

3. **Indifferent quality (I)**: These attributes refer to aspects that are neither good nor bad, and they do not result in either customer satisfaction or customer dissatisfaction with respect to the sufficiency of the attributes. Whether the attributes exist or not will not affect customers’ satisfaction at all.

4. **Attractive quality (A)**: These attributes provide satisfaction when achieved completely, but do not cause dissatisfaction when not fulfilled. Interestingly, these are attributes that are not normally expected.

5. **Reverse quality (R)**: These attributes refer to a high degree of achievement resulting in dissatisfaction due to the fact that not all customers are alike.

Kano produced a methodology for mapping consumer responses to questionnaires onto his model by a pairwise (functional and dysfunctional) of answers. By combining the two answers based on Kano evaluation table, as shown in Table 2, the
quality attributes of 5S action items in each category can be recognized and classified [7].

Table 2. Kano evaluation table [7]

<table>
<thead>
<tr>
<th>Functional answer</th>
<th>Impressed</th>
<th>Impressed</th>
<th>Indifferent</th>
<th>Indifferent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q</td>
<td>A</td>
<td>A</td>
<td>O</td>
</tr>
<tr>
<td>Improper</td>
<td>B</td>
<td>B</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Indifferent</td>
<td>B</td>
<td>B</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Disappointed</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>

2.2 Customer satisfaction coefficients
Berger et al. [21] proposed using customer satisfaction (CS) coefficients to describe whether satisfaction can be increased by meeting a quality requirement, or whether fulfilling this quality requirement merely prevents the customer from being dissatisfied. Since different customers usually have different needs and expectations, it is sometimes not clear whether a certain quality attribute can be assigned to the various categories. It is especially important to know the average impact of a quality requirement on the satisfaction of all the customers. CS-coefficient is indicative of how strongly a quality attribute may influence satisfaction or, in case of its “non-fulfillment” on customer dissatisfaction. To precisely evaluate the average impact on satisfaction, it is necessary to add the attractive and one-dimensional columns and divide by the total number of attractive, one-dimensional, must-be and indifferent responses. For the calculation of the average impact on dissatisfaction, add the one-dimensional and must-be columns and divide by the same normalizing factor [21]. The formulas for extent of satisfaction and extent of dissatisfaction are formed in Eq. (1) and (2).

Extent of satisfaction: \((A+O)/(A+O+M+I)\)……(1)
Extent of dissatisfaction: 
\[-(O+M)/(A+O+M+I)\]……(2)

A minus sign is put in front of the CS-coefficient of customer dissatisfaction in order to emphasize its negative influence on customer satisfaction if this quality attribute is not fulfilled. A positive CS-coefficient ranges from 0 to 1; the closer the value is to 1, the higher the influence on customer satisfaction. A negative CS-coefficient approaching 0 signifies that there is very little influence. Meanwhile, if it approaches -1, the influence on customer dissatisfaction is especially strong if the analyzed quality feature is not fulfilled. A value of about 0 indicates that this quality attribute does not cause dissatisfaction if it is not met [21].

3. Research Methodology
This study proposed to use Kano model to classify 5S action items into each of the quality attribute categories and use CS-coefficient to further prioritize them so that FAB managers are able to allocate available resources accordingly to meet customers’ expectations. The proposed method consists of 5 steps as shown in Fig. 2.

Fig. 2. The proposed methodology

This method was applied to a real world case of a newly built 300 mm semiconductor fabrication (called FAB A) in Taiwan. This case company has hundreds of customers worldwide. It operates many foundry sites worldwide and has been certified by ISO/TS 16949:2002, an ISO Technical Specification, which recognizes its commitment and efforts in maintaining the quality environment. Since this company has dedicated itself with high quality, top management gives full support to practice 5S activities in their family FABs in order to make the 5S work successfully. This company dedicates itself to quality on every facet of the company and sustains a culture of continuous improvements to assure customer satisfaction.

Using the proposed methodology, a stepwise procedure is described as follows.

Step 1: Prepare a 5S checklist by 5S-committee.

A 5S checklist based on the one suggested by Ho(1999) is used as an initial checklist. If the panel of 5S experts of committee accepts the initial 5S checklist, they follow instructions and present their views. If consensus is not reached, the process continues through thesis and antithesis, to gradually work towards synthesis, and building consensus. From the iterations of convergence for more significant 5S check points, a comprehensive set of feasible 5S practice checklist is gleaned. At any moment in the iteration of revising 5S checklist, the experienced participants of 5S committee can revise their earlier statements. Since the experienced
participants are involved with the sustainability that is generated from the 5S practice results in customer audit, they can evaluate the significance in each check point on 5S checklist. With all consensus on preliminary audit checklist, a feasible set of 5S audit checklist is reviewed and constructed. The resulting checklist includes 47 check points, where each check point is further expanded to between 5 to 10 action items.

Step 2: Construct Kano questionnaire

The revised checklist from Step 1 is transformed to Kano questionnaire. In the of Kano questionnaire, tens of pairwise (functional and dysfunctional) questions under the 5S practice are designed based on each of the check points. An example question is shown in as Fig. 3. To prevent the questions from ambiguity, these questions are stated with their typical examples. Thus, the respondents can answer without too much effort and provide consistent measures.

Step 3: Administer the customer interviews

According to the case company’s records, worldwide customers audit shop floor almost every day. Instead of distributing the questionnaire directly to customers, we distribute the questionnaire to the experienced and senior experts in the Quality Assurance Team of this case company. These experts served as customer representatives to sustain the questionnaire’s validity. To further attain reliability on the coverage of worldwide customers, 20 experts of each of Regional Quality Assurance Team were distributed by paper in an internal meeting and 20 copies of Kano questionnaire were immediately recorded upon returned. Before completing Kano questionnaire, these experts had been instructed stepwise with examples as shown in Fig. 3. These experts are representative from Asia, Pacific, China, Europe, Japan, North America and India, as shown in Table 3.

<table>
<thead>
<tr>
<th>Area</th>
<th>Pacific</th>
<th>China</th>
<th>Europe</th>
<th>Japan</th>
<th>N. America</th>
<th>India</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issue</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Record</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Return rates</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Step 4: Categorize check points per the result of Kano questionnaires

After retrieving and recording questionnaire results in tabulation, a pairwise (functional and dysfunctional) of answers are combined based on Kano evaluation table (Table 2), each grouping of 5S check points is identified and categorized as must-be, one dimensional, attractive, reverse, or indifferent quality attribute.

Step 5: Prioritize 5S check points by CS-coefficient

Since there will be more than one check points within the same quality attribute category, the 5S checkpoints can be ranked by CS-coefficient. Once the extent of satisfaction and extent of dissatisfaction are calculated by the CS-coefficient’s formulas, the result of CS-coefficient can rank the priority of each check points.

To beneficial from the proposed methodology, a new FAB of this case company initially adopted the Kano questionnaire result with five check points with attractive attribute and eight check points with one dimensional attribute in ramp-up stage instead of all 47 check points before. Impressively, the newly start-up FAB passed shop floor audit from its biggest customer two months ahead with the same budget resource.

4 Conclusion

This paper proposed a method to apply Kano model and CS-coefficient to assist FAB managers to prioritize those action items required for 5S practice. A real-world example is illustrated to demonstrate the effectiveness of this method. From the adoption of this proposed methodology, an influential set of specific required items in 5S practice were transformed from subjective, conceptual and linguistic practice to be identified, quantified and prioritized in semiconductor wafer fabrication under resources constraints to cater a customers’ 5S’ expectations and to generate more attention in building-up much more robust scene management.

References:


