

A Framework Based Approach for a Low Cost Factory Automation Implementation in a LED Fab

FA: Factory Automation

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Abstract – This paper discusses the approaches the OSRAM OS Malaysia team took to implement a low cost factory automation in our mixed mode capability Wafer Fab in collaboration with our business partners Vistrian Inc. By mixed mode, the paper refers to having a combination of equipment that support both remote control operations via either SECS/GEM and/or PLC control and those that are not able to be remotely operable. This is also coupled with the process complexity of running both 100mm and 150mm wafers in the same facility. As with most such implementations, the demand for a factory automation solution in this Fab was triggered by the need to improve our cost and quality position. In charting the right strategy for a factory automation implementation, the team had to first acknowledge that the equipment we have are not replaceable and therefore integrating them along with newer equipment set with higher capability is a must. This was followed by analyzing such implementations by our peer industry players and identifying key areas for improvement that would help alleviate high investment cost to achieve the desired automation level. This paper hopes to share such learnings to a wider audience and break the myth that a good factory automation solution is highly capital intensive and requires the setting up of large number of overhead resources to support such a complex implementation.

Keywords—*factory automation; factory integration; computer integrated manufacturing; system aided manufacturing; equipment integration;*

I. INTRODUCTION

In the first couple of years of the startup phase of the Wafer Fab in Malaysia, the organization encountered a high number of misprocesses due to human factors, typically wrong selection of process recipes by operators. Conventional methods of disciplining and retraining operators were not resulting in desired improvement, as might be expected, since human behavior changes are the most difficult to accomplish. This resulted in higher yield losses and a high number of lot scrappages. In addressing this problem, the team were faced with a dilemma of whether to only address this gap, or to go all out and implement the best practices of our industry peers who had already overcome such mundane issues. We chose the latter, and ventured to understand all our human and system factor gaps before addressing them. Coming from a background of not being an automation intensive organization,

the budget and the resources dedicated for this effort was very minimal in comparison to our industry peers. However, the team managed to use this to our advantage by leveraging the experiences of our peer industry players and the benchmarking activities done. This resulted in us being able to identify opportunities to skip a few gradients in learning to deploy such a solution.

II. SETTING THE RIGHT AUTOMATION STRATEGY

A. Introduce Low Invest High Automation Capability

Embracing where the organization started from and how we currently operate our manufacturing process was key to this goal. The management team knew we needed automation but we also did not wish to go overboard with our goals. We wanted to invest prudently, realize the return on investment (ROI), and scale from there onwards. The decision was made to incorporate our existing limitations into such an automation platform with an acceptable tolerance for error.

B. Designed to Scale

As a growing organization, the solution needed to not only cater to this Fab's needs but also cater for our growth as an organization. It was imperative that we should be able to scale the same solution to our existing and future Front End Fabs as well as to our Assembly & Test sites. Getting this goal right is also important to keep costs down consistently.

C. Designed-In Factory Physics Optimization

When addressing this topic on Factory Physics Optimization, the goal was not to heal all related issues in one go. The goal is to cater for initial breakthroughs in addressing issues related to operational wastages that happen in the human-machine and human-system interactions. In our implementation, this directly correlates to equipment OEE improvement, Wait Time Wastage reduction via dispatching, and correct visual management of information flow.

D. User eXperience (UX) Focused

A low invest high automation goal, in a mixed mode environment as ours which embraces our older toolsets, limits us in terms of what we could achieve in terms of mechanical automation capabilities. Deployment of Automated Material Handling System (AMHS) or RFID that do not yield the right

ROI for implementation in a low cost environment such as Malaysia were ruled out. Therefore, the solution was also designed from a bottom up perspective based on the User eXperience (UX) needs of operators rather than engineers or those with higher order capabilities. Careful selection of information made visible and streamed to an operator was key to achieving this. Therefore a simplistic, design with only the necessary input and output information visualized for both automated and manual operation was deemed necessary.

E. Platform the Application

What is meant here as “platforming” the application, is to create a holistic solution with minimal system handling complexities to do not require multiple standalone solutions to be managed to address specific problem. This is basically a measure of how the platform allows connectivity to existing or new external systems while taking over the main interface role for the key identified actions, which are configuration and validation. This approach is expected to deliver the right amount of engineering gravity for the key users, while providing the ease-of-use for the operators interacting with the system. In turn, this is expected to generate the right quality of data flow from system to system and also provide for deeper analytics and simulation capability of such data for process improvement in future [1].

III. THE SYSTEM AIDED MANUFACTURING (SAM) FRAMEWORK

The result of the above mentioned automation strategy and work that ensued is the System Aided Manufacturing (SAM) Framework. It was designed to address the listed goals in a comprehensive approach by acting as both the framework for the automation implementation as well as the User Interface (UI) for the operator interactions. The necessary visual parameters that were identified from our multiple interactions with the operators and direct observations from the manufacturing floor were merged with the Organizational (Vision, Mission, Goals & Critical Issues) and Environmental (Culture, Language, Procedures, Ergonomics, Skillset, Knowledge, etc) analysis to derive a simplistic UI that caters for a mixed mode environment such as ours.

The key visual denominators that were identified as

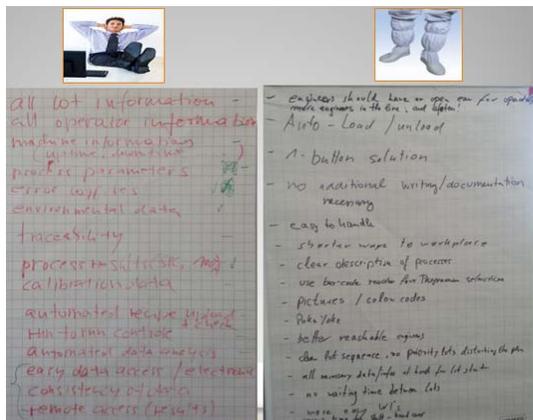


Fig. 1: The mapping of engineering and operator needs in a workshop environment.

mandatory for day-to-day usage at an operator level are listed as below:

A. Lot Identification

Operators needed to know which lots are to be transacted for a run, and to visually be aware of the current active lots running on the equipment. It was also essential that they are automatically validated by the system to ensure the correct lot is transacted at the correct equipment.

B. Process Program/Recipe

Operators needed to know the recipe with which the lot is supposed to be running and what is the current active recipe that is running on the equipment. It was also to be automatically validated by the system to ensure the correct process program/recipe is loaded on the equipment and is in fact released for a productive run. This validation is also expected to be performed automatically where the machine is capable to perform this action, and visually displayed for manual selection by operators for machines that could not perform automated process program selection.

C. Operator IDs

Another key denominator identified was the Operator ID itself. This is identified as important since the operator who transacts the lot is expected to be certified to run the lot. This layer required integration to our human resource system and was implemented as such. It was also identified that a lot in process could be handled by 2 differing operators both at the start of the process (Move In) and at the end of the process (Move Out). It was necessary to visually identify and record the details of both the differing operators. This record also serves to act as an electronic signature of the operator for the run.

D. Process Step Identifier

Although a process step identifier was found to be not key information for an operator to perform a run as the validation of runs gets automated, it was identified as key visual indicator for operations-engineering communication of run details. This is primarily because the same process programs/recipes could technically be used at different photolithography layer runs.

E. Dispatch List

We also identified that it was necessary for the solution to act as a decision support system for operators to make informed decisions in relation to a run. This is especially so with regards to deciding which lots need to be run in what prioritization order and what other lots could be batched together in a run. In order to achieve this the framework integrated to our Manufacturing Execution System (MES) for real time dispatch list prioritization based on equipment, recipe, lot critical ratio, lot status and queue time details. The dispatch list also allows the system to accurately capture the utilization status of the equipment to reduce wait time wastages incurred due to a “No Personnel” and or “No Material” status and allows escalation by the supervisory team to ensure higher level of equipment utilization.

The key visual denominators that were identified as **supplementary** for the day-to-day usage at an operator level are listed as below:

A. Production Info

A Production Info is OSRAM OS speak for a special engineering run instruction. It was imperative that deviation from the standard runs need to be managed in an electronic manner with the right visualization to operators and acknowledgement at run-time and made available for traceability purposes. This was achieved by streaming the

Precedence Rule Settings				
PRECEDENCE	LOT ID	EPA	EQP ID	ROUTE
1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
4	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
5	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
7	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
8	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
9	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
10	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
11	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
12	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
0	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
0	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
0	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Fig. 2: The Precedence Rule created to stream Production Info to operators.

Production Info at run-time, ONLY wherever and whenever it was deemed active (based on certain conditions that need to be matched) upon completing an approval loop and fulfilling the allowed Precedence Rule (a rule that manages conflicts between multiple production info). Additionally, it would also require the operators to acknowledge the Production Info before allowing a Move In or Move Out of a lot from the process step.

B. Deviation Information

We also found that it was important for some of the process to know if there was any deviation that had taken place in earlier runs. For this we decided to also visualize the Deviation details and provide links to the deviation system for reference by the affected process at run-time ONLY wherever and whenever there was a deviation.

C. Electronic Lot Traveler

As part of the automation initiative, we were also doing away with hardcopy Lot Travelers. In doing so, we needed an alternative for operators to be able to see the current state of a lot. Therefore the ELT tab was created for the operators to interact with the system to identify the process steps and equipment to which the lots belong.

D. Electronic Data Collection (EDC) & Loss/Bonus

The framework should also cater to accept manual EDC and Loss/Bonus to information that were not readily available

from equipment especially for ~50% the equipment in our footprint that were limited in their integration capabilities.

E. Instruction

There were also some run related information, especially on the handling of the wafers and actions needed to be taken for handling of manual equipment that needed to be communicated to the operators. These pieces of information were retrieved from the MES system and displayed in the UI as well.

F. Messages

We also needed a field to communicate the system-to-system and system-to-equipment related validation failures to the operators for correction and/or to trigger escalations. Those communications are visually handled through this display.

These findings from our gap analysis and needs analysis were then studied and then translated into how the SAM Framework and the corresponding UI was designed. This includes identifying the necessary connectivity to the external systems and background validation of the necessary information, without flooding the users viewing screens.

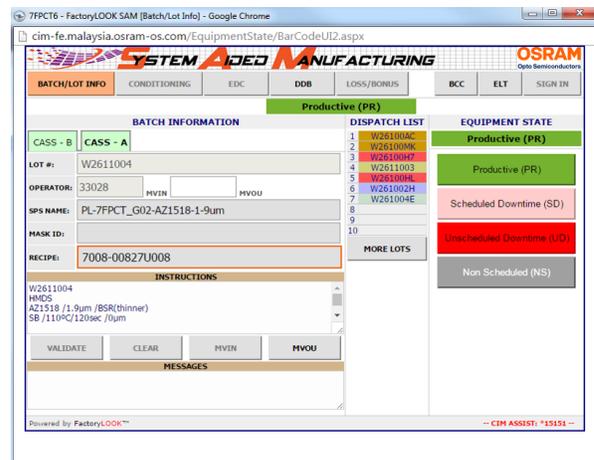


Fig. 3. The SAM User Interface.

IV. THE RESULT

One of the key advantages we recognized during the design stages of such an implementation was that it provided us an opportunity to move away from a station controller based implementation to client-server architecture where the common control and validation layers would be able to be made available on ALL UI instances centrally from the server. This essentially reduces the time needed to introduce changes to the system and ensures the same change, enhancements, factory physics calculations are applicable in a standardized manner to all equipment.

This resulted in the Equipment Integration (EI) instance only containing the necessary Remote Control interactions needed without worrying about other logic at the EI level. This also helps in standardizing and reducing the flavors of the EI

codebase from Model specific to capability specific i.e we would require only one codebase for all single chamber, single load port tools irrespective of the models and one codebase for 2 load port tools irrespective of the models. ALL the necessary remote command and status variable configurations were able to be handled at a configuration file level. This essentially reduced the EI release for our standard equipment from a typical 30 days to 0.5 days.

What this translated to was the ability to keep the number of automation engineers needed to deploy and sustain such a solution to 2 engineers per 150 equipment (without including the resources from our solution provider partner, Vistrian) essentially keeping our overhead cost very low in comparison with our peer semiconductor companies.

More importantly for the organization, operationally we were able to see a return on investment within 0.8 months simply by preventing the nagging misprocess occurrences that were plaguing us, and which was the catalyst for such an implementation. This consistently yielded returns of 1 Mio Euros per year in savings. Additionally, the ability to go paperless gave us a gain from 0.5% to 2% depending on the product family essentially reducing losses arising from particle contamination from paper usage and ink transpiration.

The real time dispatch list integration to the SAM Framework helped the organization manage our wait time wastages resulting in an overall improvement of 13% for our productive time when normalized by the volume. We were also able to reduce our No Material time by 29% while being able to accurately calculate our No Personnel time which showed us

misleading data prior to this implementation.

In terms of direct labor efficiency, we managed to increase our headcount efficiency from 20 operators / 100 wafer starts to 16.5 operators / 100 wafer starts. This was only possible because the framework design not only focused on the gap analysis but also the needs analysis from a bottom up approach.

Most importantly, the biggest accomplishment we feel proud of, is the seamless transformation of a running Fab with a problem free introduction of such large scale change.

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REFERENCES

- [1] Mark Bonchek and Sangeet Paul Choudary, "Three Elements of a Successful Platform Strategy," Available at: <https://hbr.org/2013/01/three-elements-of-a-successful-platform>

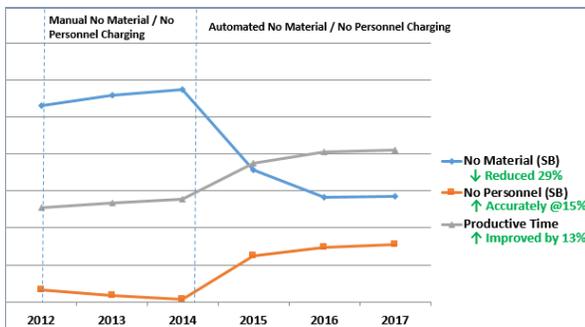


Fig. 4: Wait Time Wastage (WTW) data showing improved Productive Time and No Material Time, while accurately capturing the No Personnel Time.