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MODELING AND SIMULATION OF CLUSTER TOOLS WITH EQUIPMENT FRONT-END MODULE

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ABSTRACT

In the semiconductor manufacturing industry, cluster tools are widely used for most wafer fabrication process such as photolithography, etching, deposition, and even inspection. To improve the performance of semiconductors, the wafer circuit width has been shrunk dramatically. Since this makes complexity of scheduling problems high, a sophisticated simulation model is needed to test and verify the various scheduling method. Most of the previous research have been focused on Vacuum Module (VM). However, the scheduling problem of Equipment Front-End Module (EFEM) has recently been emphasized, and bottleneck begins to occur also in EFEM. Therefore, in this study, we propose a new modeling method that includes EFEM which was not considered in the past.

1 INTRODUCTION

A Cluster tool has VM and EFEM, which are major two parts, and loadlock which supports the connection between two parts. VM is a high-value part which handles the actual wafer fabrication process. It consists of several single-wafer process module (PMs) and Vacuum Transport Module (VTM), a wafer handling robot. EFEM supplies wafers from the wafer-lot to the VM one by one. It consists of several wafer-lot load-ports (LPs), a wafer aligner and Atmosphere Transport Module (ATM), a wafer handling robot. Since VM is operated in vacuum and EFEM is operated in the atmospheric pressure, it is impossible to transfer wafers directly between two parts. Therefore, an intermediate buffer called loadlock assists wafer transfer between them. It exists between VM and EFEM, maintaining vacuum when working with VM, and atmospheric pressure when working with EFEM. The entire tool configuration is illustrated in Figure 1.

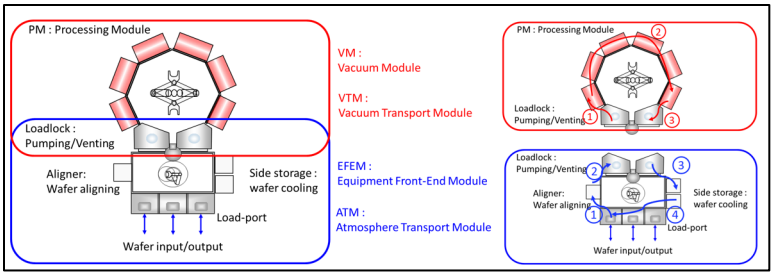

Figure 1 : Cluster tool with EFEM and loadlock.

Many previous studies on modeling cluster tools have mainly focused on VM part. (Shin et al 2001) proposed the modeling methods and implemented a real-time scheduler for dual-armed cluster tools. (Joo and Lee 2001) proposed virtual cluster tools that mimics a real cluster tool and the cluster tool controller.

(Lee and Lee 2010) proposed open scheduling architecture for cluster tools. However, all of them didn't have any modeling method for EFEM. Therefore, this study proposes a modeling method considering EFEM and loadlock based on Extended Finite State Machine (EFSM) and (Joo and Lee 2001).

2 MODELING AND SIMULATION

EFSM is an extension of Finite State Machine(FSM) which models complex system behavior (V.S. Alagar et al 2011). Each part of the cluster tool is related to each other, and at the same time it must satisfy the logical control specifications. EFSM is able to express this control specification as the condition of transition. Therefore, we have modeled each part with EFSM, including control specification of the tool.

The simulation of cluster tool is discrete event-based synchronization of all EFSMs. This simulation is configured to match the real world requirements in the actual FAB. EFSM models for each part of the cluster tool are illustrated in Figure 2.

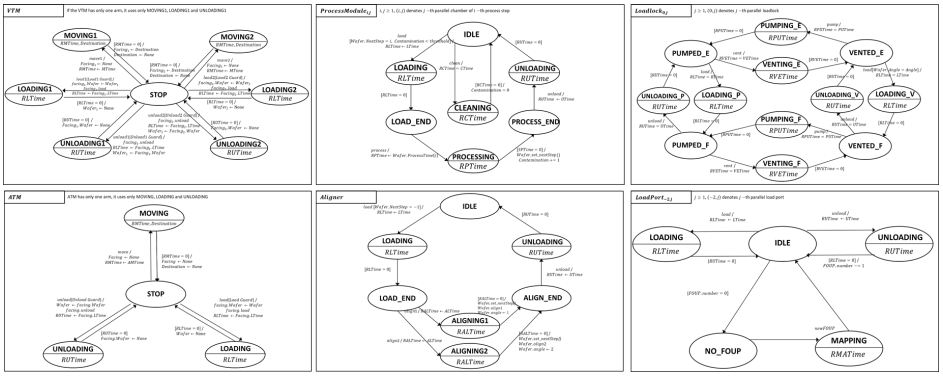

Figure 2 : EFSM Modeling for each part of cluster tool.

The biggest benefit of the above modeling method is that it can easily identify all possible states of cluster tool by generating synchronous product from all EFSMs. With generated synchronous product, we can easily develop algorithms that prevent deadlocks by trimming operations.

3 CONCLUSION AND FUTURE WORKS

We proposed modeling method and simulation of a cluster tool with EFEM and loadlock based on EFSM. This modeling method not only simulates scheduling of the cluster tool, but also facilitates the analysis of each part. In addition, this method makes deadlock prevention easier, which is one of the most difficult problems in scheduling of the cluster tool. Currently, scheduling optimization research using reinforcement learning is underway based on the above modeling and simulation.

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