

Chapter 39

Real-Time Scheduling and Control of Single-Arm Cluster Tools With Residency Time Constraint and Activity Time Variation by Using Resource-Oriented Petri Nets

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ABSTRACT

In semiconductor manufacturing, when a wafer is processed, it requires unloading from its process module in a given time interval, otherwise it is scraped. This requirement is called wafer residency time constraints. Thus, it is crucial to schedule a cluster tool such that the wafer sojourn time in a process module is within a given time window to satisfy the wafer residency time constraints. Besides wafer residency time constraints, in a cluster tool, the activity time is subject to variation. The activity time variation can make a feasible schedule obtained under the assumption of deterministic activity times become infeasible. To solve this problem, it is important to reveal the wafer sojourn time fluctuations with bounded activity time variation. Such an issue is addressed in this chapter for single-arm cluster tools. A single-arm cluster tool is modeled by a resource-oriented Petri net to describe the wafer fabrication processes. Based on it, a real-time control policy is proposed such that it offsets the effect of the activity

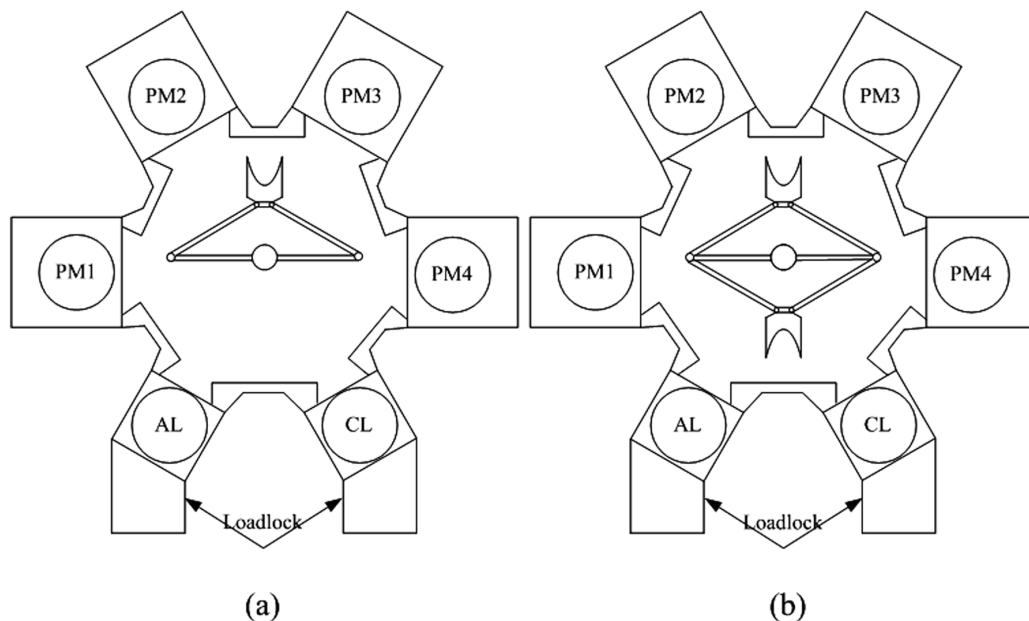
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time variation as much as possible. Then, the wafer sojourn time delay in a process module is analyzed and analytical expressions are derived to calculate the upper bound. With the help of the real-time control policy and wafer sojourn time delay analysis results, schedulability conditions and scheduling algorithms for an off-line schedule are presented in this chapter. The schedulability conditions can be analytically checked. If schedulable, an off-line schedule can be analytically found. The off-line schedule together with the real-time control policy forms the real-time schedule for the system. It is optimal in terms of cycle time minimization. Examples are given to show the application of the proposed approach.

1. INTRODUCTION

In semiconductor manufacturing, a cluster tool is widely used to process wafers one by one with single-wafer processing technology because it can achieve better quality control for processing large-sized wafers, such as 300mm ones and reduce the fabrication lead time. A cluster tool consists of several processing modules (PM), an aligner, a wafer handling robot, and two loadlocks for wafer cassette loading/unloading. In general, a cassette has 25 wafers with an identical recipe (Kim *et al.*, 2003; and Lee and Park, 2005). Raw wafers are loaded into the system through a loadlock, visit one or more PMs in a pre-specified order (each wafer should stay in a PM for a minimum time in each step to get processed), and return to the loadlock where they come from (Wu *et al.*, 2008a). By using such a tool, it can provide a flexible, reconfigurable, and efficient environment for semiconductor manufacturing (Bader *et al.*, 1990; and Burggraaf, 1995), resulting in higher yield (Newboe, 1990), shorter cycle time (McNab, 1990; Newboe, 1990; and Singer, 1995), better utilization of space (Burggraaf, 1995; and Singer, 1995), and lower capital cost (Singer, 1995). For a cluster tool, the wafer handling robot can be a single or dual-arm one as shown in Figure 1 (a) and (b), respectively.

Figure 1. The cluster tools: (a) single-arm robot; (b) dual-arm robot



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