PHOMAG : A Photolithography Machine Allocation Game*

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Abstract

In this paper, a computer simulation-based decision aid system is designed to serve as an interactive what-if analysis for dynamic allocation of photolithography machines in a fab. The system, PHOMAG, is featured by a full scale fab simulation model using ManSim™, incorporation of interactive user-defined/dispatching decision to the simulator using UserAccess™ and a user friendly GUI on PC/Windows95™. PHOMAG has been implemented in the field with positive user feedback.

1. Introduction

Dynamic equipment (machine) capacity allocation in a semiconductor fab is critical to fab performance such as output volume, cycle time and on time delivery. The development of an effective dynamic capacity allocation strategy is technically very challenging due to the complexity of fabrication processes, a large number of heterogeneous machines, re-entrant nature of process flows, and machine uncertainties. The challenge is even more difficult in a foundry fab due to its diversity of product types and low production volume of individual products.

In this paper, we consider the dynamic allocation of machine capacity in a foundry fab over a time horizon of one day. In the beginning of one day, the number of wafers to be processed (target moves) at individual steps by the end of the day are first determined. To process a wafer fabrication step, it requires the availability of both an appropriate machine and wafers ready for the step (WIP). An allocation of machine capacities to process WIPs at individual steps changes the WIP distribution of a fab; in turn, a new WIP distribution and/or a new machine availability status may result in an adjustment of machine capacity allocation. The problem is then how machine capacities should be dynamically allocated to individual fabrication steps so that daily target moves can be achieved.

As a first phase of research and development, this paper focuses on the photolithography (PHOTO) steps and machines since they usually play a critical role in the production flow control of a fab. A computer simulation-based decision aid system is developed to serve as an interactive what-if analysis (game) tool for production flow control engineers.

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2 PHOMAG System Description

The PHOMAG system shown in Figure 1 consists of three main modules:

(1) a full scale fab simulation model using the ManSim simulator,
(2)an interface developed over User Access for enforcing machine allocation and wafer lot selection in the ManSim simulator,
(3) a GUI that allows engineers to update the simulation model, to set machine allocation to individual steps, to run a simulation and to review simulation results.

Through the GUI running on a PC, an user may load the latest, necessary manufacturing execution system data and the daily target moves (called a KSR-2 file) from a VAX™ computer into the ManSim simulation model. The user can allocate photo machines to individual photo steps by setting the machine allocation table with process limitations and priority assignment included. Currently, machine allocation is set every three hours. After a simulation is run, the user may review the result and evaluate the machine allocation decision in a familiar output format via the GUI. ManSim simulator and the User Access program are run on a HP workstation/UNIX and the GUI on a PC/Windows95. Interfaces are also developed to facilitate the communications among the HP workstation, PC and VAX computer.

2.1 ManSim Simulation Model

The model is a full-scale simulation model for a 6" wafer fab with monthly volume of 38000. It has more than 200 product types, about 300 fabrication steps for each product type, and more then 300 machines. Production constraints for individual machine types are also considered, such as the single mask availability constraint for PHOTO machines, batching operations of furnaces and setup time effect at implantation. In the model, lot dispatching to machines adopts the FIFO rule except for the PHOTO machines.

2.2 Photo Machine Allocation via User Access

User Access is a ManSim option that allows us to develop user defined functions that can interact with ManSim simulation. A user-defined PHOTO machine allocation function is a C program that collects and judges the simulation data and then sets the new parameters to ManSim by using the interface provided by User Access as follows.

(1) Read in Machine Allocation: At the beginning of our simulation, the simulator reads in the machine allocation set by a supervisor via GUI on a PC/Windows95.

(2) Get Lot Information: After a fabrication step of a lot, say lot A, is completed in the simulation, ManSim generates an event (U_EVENT_DONE) to trigger User Access. At that time, User Access retrieves the necessary data of lot A from ManSim via:

1. uget_lot_infos() for getting the lot identification, the status, the priority, the dispatching priority, the product name and the current step of the recipe related to the lot.
2. uget_step_infos() for getting the step number, its description and the operation description related to the process recipe step.
3. uget_processed_lot() for getting the name of the machine that processed lot A.

(3) Decide The Next Lot : If the machine is not a PHOTO machine, simply return from User Access back to ManSim simulation. If the machine is a PHOTO machine, get the information of all the lots in queue of photo machines via function uget_next_queue_entry(), and filter out the lots that can be dispatched to the machine; then select the lot, say lot B, with the least slack time among them by using the slack dispatching rule of ManSim.

(4) Set Lot Priority to ManSim : Lot B dispatched to the machine by using the u_force_lot_on_eqp() function to bypass the ManSim internal dispatching, loading and setup rules and to enforce the machine to load lot B.

2.3 Data Link and Interprocess Communications

Data flow and interprocess communications of PHOMAG are depicted in Figure 2, where GUI is a client on a PC/Windows95 platform and the PHOMAG simulator is a server on a HP/UNIX platform communicating over a TCP/IP protocol. We use TELNET to establish the connection between these two platforms and FTP to exchange data files. The system is designed so that a supervisor can directly execute the machine allocation simulation without taking the trouble to learn the complexity of workstation instructions and parameter setting process.

2.4 GUI Display

Initializing the PHOMAG system on PC/Windows95, we shall first see the welcome page, which will close after a TCP/IP connection is established. Then, the Fab Area Map shows up and a supervisor may use it to select the working area for machine allocation.

After selecting the PHOTO area, PHOMAG changes to display a machine allocation table as shown in Figure 3. In this table, PHOTO machine names and their associated photoresist are listed in the first and second columns, PHOTO stage names are listed in the first row. PHOMAG system will automatically mask the block of each stage-machine pair that is not admissible. To assign machines to stages and to achieve machine backup sharing effect, a supervisor can set the unmasked blocks by clicking the mouse over individual blocks.

After setting the machine allocation table, simulation can be run by using the "siM" menu. Simulation results are displayed by the Report functions. Figure 4 gives an example.

3. Conclusion

PHOMAG has been implemented in the field. It demonstrates the following values to users: (a) to assist in better machine allocation and setup reduction, (b) to serve as a basis of communication among different user and lead to consensus on lot dispatching, (c) to forecast daily outputs, (d) to provide a reference for maintenance scheduling and (e) to be used as a training tool of scheduling/dispatching.

Reference

[1] Tyecin System Inc, "ManSim/X user manual", 1996.

[2] Robert C. Juba, Paul N. Keller, Alton F. Verity, "Production Improvements Using a Forward Scheduler", Proceedings 1995 IEMT Symposium, 205-209.

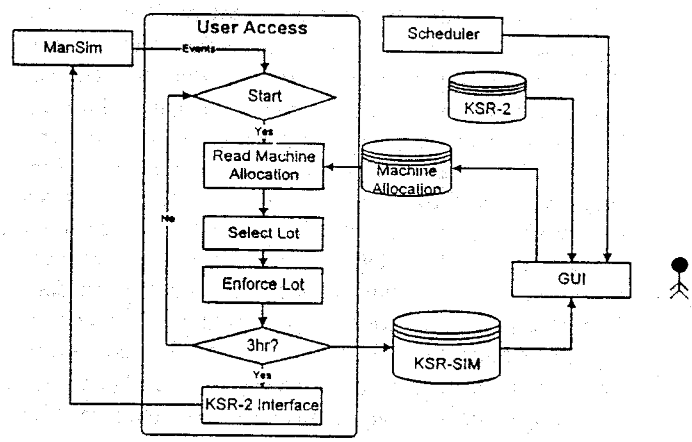


Figure 1 System Architecture of PHOMAG

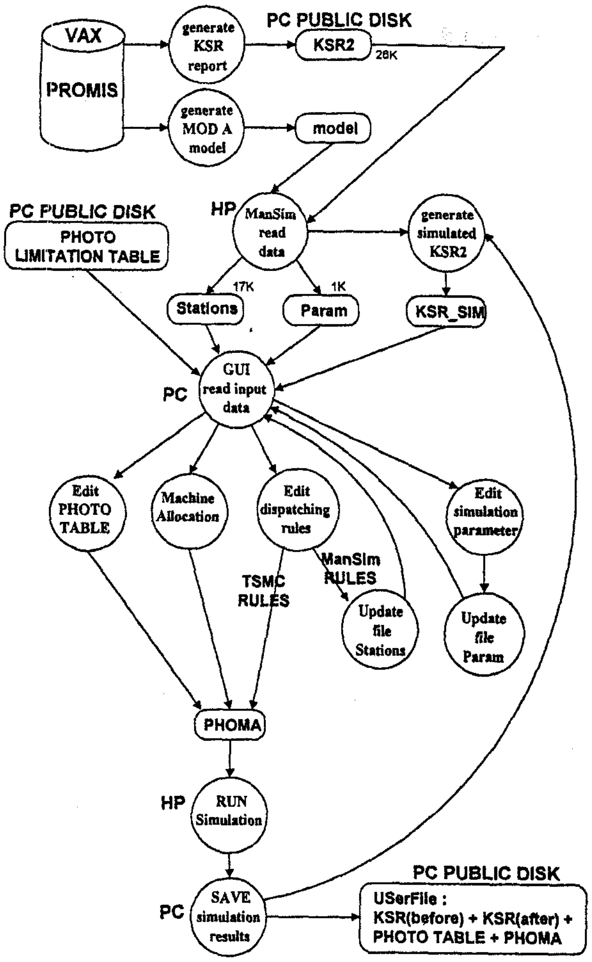


Figure 2 Data Flow Diagram

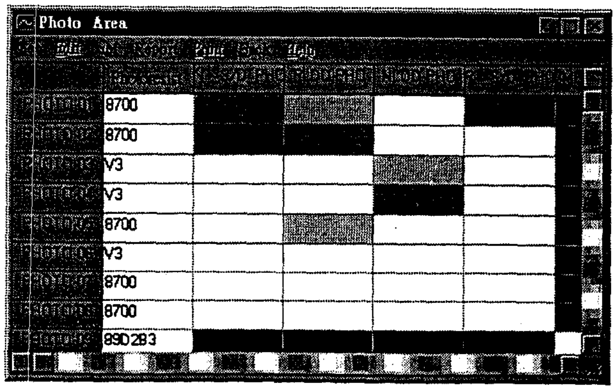
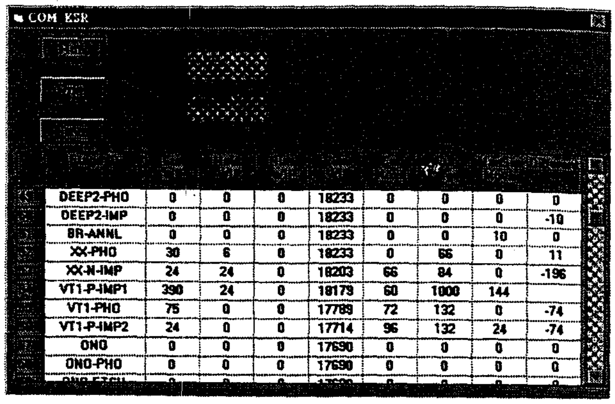


Figure 3 Machine Allocation Table



DEEP2-PHO	0	0	0	18233	0	0	0	0
DEEP2-IMP	0	0	0	18233	0	0	0	-10
BR-ANNL	0	0	0	18233	0	0	10	0
XX-PHO	30	6	0	18233	0	66	0	11
XX-N-IMP	24	24	0	18203	66	84	0	-196
VT1-P-IMP1	390	24	0	18179	60	1000	144	
VT1-PHO	75	0	0	17789	72	132	0	-74
VT1-P-IMP2	24	0	0	17714	96	132	24	-74
ONO	0	0	0	17690	0	0	0	0
ONO-PHO	0	0	0	17690	0	0	0	0

Figure 4 Simulation Results