SHENZHEN UNIVERSITY 深圳大学

CS152

CYCLIC SCHEDULING OF SINGLE-ARM CLUSTER TOOLS WITH MULTIPLE WAFER TYPES: A CASE STUDY

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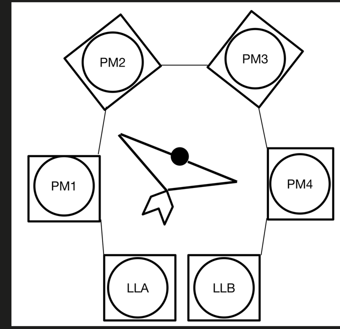
Introducion

1. CHIP SHORTAGES, INCREASING WAFER SIZES, AND DIVERSE DEMANDS HAVE MADE IT IMPERATIVE TO PROCESS MULTIPLE TYPES OF WAFERS SIMULTANEOUSLY；
2. WHEN A WAFER IS PROCESSED, IT NEEDS TO RESIDE IN THE PROCESSING CHAMBER FOR A CERTAIN AMOUNT OF TIME. THE PROCESSING TASK CANNOT BE COMPLETED IF THE DWELL TIME IS TOO SHORT, AND THE WAFER WILL BE DAMAGED IF THE DWELL TIME IS TOO LONG；
3. IN THIS PAPER, THE SCHEDULING PROBLEM OF CLUSTER TOOLS WITH MULTI-TYPE WAFERS IS STUDIED, INCLUDING ROBOT HANDLING JOBS SEQUENCING AND WAFER PROCESSING SEQUENCING.



SINGLE-ARM CLUSTER TOOLS

Description of the problem

1. THE CLUSTER TOOL IN THIS PAPER IS COMPOSED OF A ROBOT ARM, SIX PROCESSING CHAMBERS AND TWO LOADING STATIONS.
2. SUPPOSE W (W>=2) DIFFERENT TYPES OF WAFER ARE PRODUCED IN A WAFER PRODUCTION CYCLE, AND THE TYPES OF WAFERS ARE LABELED 1,2,3... W.
3. THE DIFFERENT TYPES OF WAFERS ARE MOVED FROM THE LOADING STATION ENTER THE CLUSTER TOOLS ACCORDING TO THE RESPECTIVE PROCEDURES . WHEN ALL THE PROCESSES OF ALL WAFERS ARE COMPLETED, THEY ARE MOVED TO THE UNLOADING STATION AND THEN LEFT THE CLUSTER TOOL.

W	type of wafer
(w,i)	The i-th processing procedure of the w-th wafer
$[a_{wi},b_{wi}]$	The processing time window of type w-wafer in i-processing chamber
move(w,i)	The process of moving a w-type wafer from its i-processing chamber to the next processing chamber by the robot arm
α	the time it takes a robot to unload a wafer
β	the time it takes a robot to load a wafer
θ	the time it takes for a wafer to move between processing chambers

DEFINITION OF SYMBOLS

T	The time it takes to produce a wafer lot
P_{wi}	The time required for w-type wafer to be processed at i-processing chamber
t_{wi}	The start time of robot arm carries w-wafer from i-processing chamber to the next processing chamber in a wafer lot
$y_{wi,w`i`} = \begin{cases}1, & t_{wi} \le t_{w'i'} \\ 0, & t_{wij} \ge t_{w'i'}\end{cases}$	$t_{wi} \le t_{w'i'}$:move (w,i) starts earlier than move(w',i'), $y_{wi,w`i`}$=1; $t_{wi} \ge t_{w'i'}$:move (w',i') starts earlier than move(w,i), $y_{wi,w`i`}$=0.

DEFINITION OF VARIABLES

Establishment of model

1. CONSTRAINTS OF PROCESSING TIME WINDOW
2. CONSTRAINTS OF THE HANDLING CAPACITY OF ROBOT ARMS
3. CONSTRAINT OF PROCESSING CYCLE TIME
4. CONSTRAINTS OF SHARING PROCESSING CHAMBERS

The minimum of processing cycle time	T
Constraints of processing time window	$a_{wi} + \alpha + \theta + \beta - M(1 - y_{w(i-1),wi}) \le t_{wi} - t_{w(i-1)}$ $t_{wi} - t_{w(i-1)} \le b_{wi} + \alpha + \theta + \beta + M(1 - y_{w(i-1),wi})$ $a_{wi} + \alpha + \theta + \beta - M(1 - y_{w(i-1),wi}) \le T + t_{wi} - t_{w(i-1)}$ $T + t_{wi} - t_{w(i-1)} \le b_{wi} + \alpha + \theta + \beta + M(1 - y_{w(i-1),wi})$
Constraints of the robot arms`s capacity	$t_{wi} - t_{w'i'} \ge \alpha + \theta + \beta + \theta - My_{wi,w'i'}$ $t_{w'i'} - t_{wi} \ge \alpha + \theta + \beta + \theta - M(1 - y_{wi,w'i'})$
Constraint of processing cycle time	$T \ge \alpha + \theta + \beta + \theta$
Constraints of sharing chambers	$y_{31,41} \le y_{31,32}$ $y_{31,41} \le y_{31,40}$ $y_{31,41} \le y_{32,40}$ $y_{31,41} \le y_{32,41}$ $y_{31,41} \le y_{40,41}$ $1-y_{31,32} \le y_{40,41}$ $1-y_{31,40} \le y_{40,41}$ $1-y_{32,40} \le y_{40,41}$ $y_{31,41} \le y_{40,41}$ $1-y_{31,32} \le y_{32,40}$ $1-y_{40,41} \le y_{32,40}$ $y_{31,40} \le y_{32,40}$ $y_{32,41} \le y_{32,40}$ $1-y_{32,40} \le y_{31,32}$ $1-y_{32,41} \le y_{31,32}$ $1-y_{40,41} \le y_{31,32}$ $y_{31,40} \le y_{31,32}$ $y_{31,32}+y_{32,40}+y_{40,41} \le y_{31,41}+2$ $y_{31,32}+y_{32,40}+y_{40,41} \le y_{32,41}+2$

Examples

1. THE TIME OF LOADING, UNLOADING AND MOVING BETWEEN THE PROCESSING CHAMBER IS 3S, 6S AND 6S RESPECTIVELY.
2. A PRODUCTION BATCH WAFER TYPE IS FOUR, ALL TYPES OF WAFER PROCESSING NUMBER IS 1.

THE PROCESSING PROCEDURE OF EACH WAFER

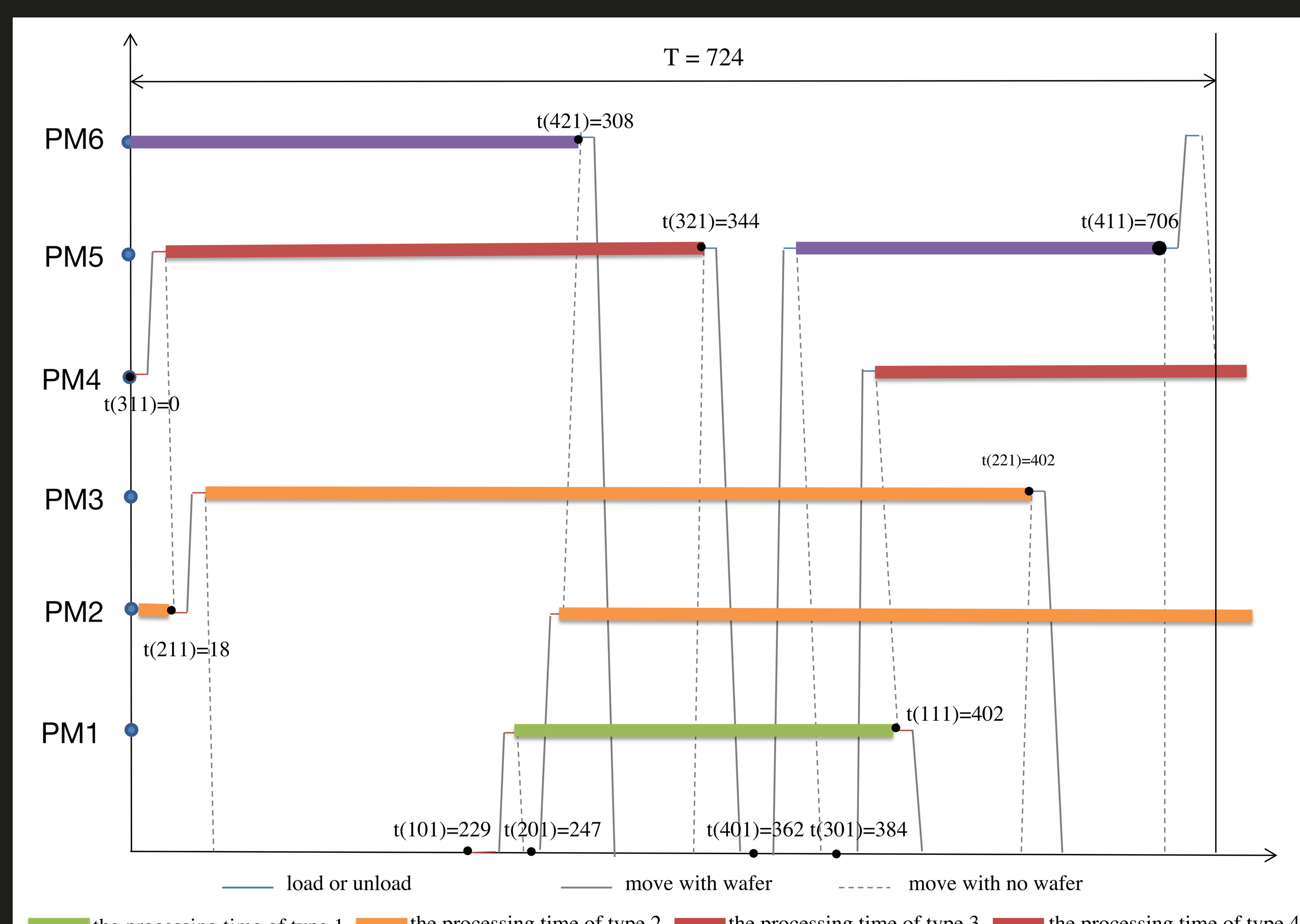
Wafer type	Manufacturing procedure
Type 1	PM0→PM1→PM7
Type 2	PM0→PM2→PM3→PM7
Type 3	PM0→PM4→PM5→PM7
Type 4	PM0→PM5→PM6→PM7

PROCESSING TIME WINDOWS OF WAFERS IN SIX PROCESSING CHAMBERS

W	a_{w1}	a_{w2}	b_{w1}	b_{w2}
1	142	158	/	/
2	480	507	516	537
3	297	325	329	353
4	329	353	311	337

Conclusion

1. AFTER RUNNING FOR 0.01S, THE OPTIMAL PRODUCTION CYCLE TIME OF THE SCHEDULING PROBLEM WAS 724S, INDICATING THAT THE CLUSTER DEVICE COULD PROCESS FOUR DIFFERENT TYPES OF WAFERS IN ABOUT 12 MINUTES.
2. THIS SHOWS THE PRACTICABILITY AND RAPIDITY OF THE MODEL.



CYCLIC SCHEDULING