DAILY REQUIRED SHIPOUT OPTIMIZATION IN FABRICATION PROCESS

NUS National University of Singapore

IE3100M/ IE3100R SYSTEMS DESIGN PROJECT
AY2021/22
DEPARTMENT OF INDUSTRIAL SYSTEMS ENGINEERING & MANAGEMENT

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01 OVERVIEW

COMPANY BACKGROUND

- Micron Technology, INC is founded in 1978
- Currently the 4th largest semiconductor company in the world
- One of the world leaders in inventing memory solutions, developing and manufacturing memory and storage technologies
- Spread across 17 countries, 13 manufacturing sites and 14 customer labs

PROJECT DESCRIPTION

To develop an optimization model to plan daily required movement of wafers lots during fabrication process to maximize long term output production to meet customer demand. Some important considerations include Fabrication Cycle Time, Buffer Work-In-Progress (WIP) requirements, Time Bucket, Required Run Rate/Demand and Available tools for a given step

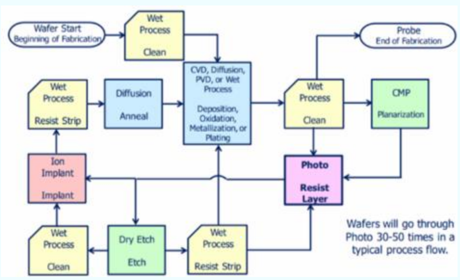
OBJECTIVES

To propose an optimization model that:

☑Can be integrated into multi-tier scheduling system
☑Schedules the daily movement of wafer lots
☑Increase overall efficacy of output production
☑Able to meet the customer demand while keeping the constraints

02 PROBLEM BACKGROUND

PROCESS FLOW



CURRENT APPROACH

Micron Advanced Scheduler (MAS), consists of 2 components, Target Generation (TG) and Area Balancing (AB)

AB uses Discrete Event Simulation to adjust scheduling prioritization and takes daily required move signal of wafer lots from TG during fabrication process

TG uses simple heuristic method to calculate daily required move of wafer lots by looking at downstream WIP, demand and historical CT

PROBLEM IDENTIFICATION

TG's simple heuristic method is not optimized, hence production's efficiency is not optimized

Plans generated from TG might be infeasible sometimes as upstream and downstream are planned independently, causing operation steps to miss demand

THUS, THE PROJECT FOCUS ON DEVELOPING AN OPTIMIZATION MODEL TO OPTIMIZE THE DAILY REQUIRED MOVEMENT OF WAFER LOTS DURING FABRICATION PROCESS TO INCREASE OVERALL EFFICACY OF OUTPUT PRODUCTION RATE

03 METHODOLOGY

04 DATA QUERYING

```
var R = SampleModel_01;

var shipout = from a in R.ShipOut
          select new
          {
          a.StartDateTime,
          a.ShipQty,
          a.QuestDate,
          a.Schedule,
          a.Destination
          };

shipout.Dump("shiout_r");
Util.WriteCsv(shipout,@"c:\Users\Desktop\shipout.csv");
```

During data processing, a query was written with C# coding language in LINQPad to retrieve relevant data from Micron's database required for our modelling

05 MATHEMATICAL MODEL

OBJECTIVE FUNCTION:

MAXIMIZE OVERALL CUMULATIVE OUTPUT AMOUNT OF WAFERS READY FOR DELIVERY TO CUSTOMERS

$$totalShipOut = \sum_{fu \in FlowUnits, t \in T} Ship_{(flowUnit,t)}$$

CONSTRAINT #1:

Flow balance equation for wafers belonging to flowUnit∈FlowUnits

- $availableWIP_{fu,1,(t+1)} = availableWIP_{fu,1,t} - schedule_{fu,1,t} + waferStart_{fu,t}, \forall t \in T^{new}$
- $availableWIP_{fu,s,(t+1)} = availableWIP_{fu,s,t} - schedule_{fu,s,t} + schedule_{fu,s-1,(t-PT_{fu,s-1})}, \forall t \in T^{new}, s \in Steps_{fu} | s > 1$
- $Ship_{fu,t+1} = Ship_{fu,t} + schedule_{fu,LS_{fu},(t-PT_{fu,LS_{fu}})}, \forall t \in T^{new}$
- $availableWIP_{fu,s,0} = currentAvailableWIP_{flowUnit,step}$

CONSTRAINT #2:

Machine Capacity Constraint

$$\sum_{(fu,s)} rpt_{fu,s} \times schedule_{fu,s,t} \leq r \times capacity_0$$

CONSTRAINT #3:

Minimal output constraint

$$Ship_{fu,t+1} \geq \sum_{\tau=1}^{t} demand_{fl,\tau}, \forall fu \in FlowUnits, t \in T^{new}$$

06 RESULTS

```
Barrier solved model in 38 iterations and 88.06 seconds (34.95 work units)
Optimal objective 7.54283789e+04
```

75,000 units of wafers readily produced in 3.5 weeks, which is more than the demand required of 60,000 in 3 weeks!

*(Dataset used in our model is a set of synthetic data due to the privacy policy, hence results generated here is not 100% accurate in reflecting Micron's real demand and output)

07 ASSUMPTION

Steps that have 0 processing time are considered immediately done and skipped if the previous step is done

Machine capacity constraint uses the summation of all products of *rpt* and *schedule* per time period

Waferstart calculation can fulfil the intermediate demands before their due date

08 LIMITATION

Computer's RAM is limited; hence optimization model might not be able to produce results or output when memory is full

Time period is being rounded up when there is decimal involved as it acts as an index in our dataset, which may potentially cause *waferstart* to be underestimated, thus impacting the accuracy of our model

09 ACHIEVEMENTS

SOLVED THE 2 MAIN PROBLEMS IDENTIFIED

Output production is optimized and meet demand

Model serves as good foundation for more robust model in the future

RECOMMENDATIONS

Integrate a cloud server so we have sufficient memory to use, which will prevent any 'memory ran out' error

Varying the unit of time period such that no decimals will be involved/reduce the occurrence of decimals in time period to improve accuracy of results

TECHNICAL SKILLSETS

✅PROJECT MANAGEMENT
MATHEMATICAL MODELLING✅
✅OPERATIONS RESEARCH
PROCESS OPTIMIZATION✅
✅DATA PROCESSING
MACHINE LEARNING✅