



Project Overview

Problem Description

The photolithography process is highly complex and dynamic. Variables such as planned tool down and process holds are common sources of disruption. This inherent variability results in frequent deviation from the forecasted run rates, affecting the photoresist consumption as Consistent of monitoring well. photoresist inventory is needed to anticipate and resolve any excess or shortages.

Optimization of Photo Inter-workstation Capacity Balancing and Material Usage through Scheduling Logic Automation

Department of Industrial Systems Engineering and Management (ISEM) IE3100M Systems Design Project (Group 10)

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Current Approach by Micron

The Materials Team is responsible for monitoring photoresist inventory levels and anticipating excess or shortage.

The **Photolithography Team** is responsible for adjusting planned run rates at the inter-workstation pairs based on feedback from the Materials Team to resolve inventory gaps.

Key Problems:

- 1. Inefficient communication between both departments
- 2. Periodic review process is performed with a review period of one month, leading to slow response times.



 \checkmark Recommend adjustments to the forecast to resolve anticipated inventory gaps

Implementation of Solutions Approach

PART III: Linear Programming on Python



PART I: Historical Data Analysis

Tableau Dashboard allows the user to visualize deviations (actual – planned) in run rate of the Design ID for the respective Step, Workstation, Material Description and Work Week.

Tracking signal can help determine if forecast is bias – over forecasting or (+)under forecasting.

Key Objectives of Proposed Solution

- ✓ Improve response time and adaptability to disruptions
- \checkmark Provide a common data platform to enhance collaboration
- ✓ Automate and standardize calculations to monitor photoresist inventory



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PART II: Excess and Shortage

Calculations were automated using figures of the

- 1. Real time inventory levels to get the Quantity on Hand (QOH)
- 2. Batch expiry dates
- 3. Forecasted run rates

Anticipating Excess: Cumulative bottle consumption at any time within the future 13 Micron work weeks < Cumulative number of bottles reaching expiry by that time

Anticipating Shortage: Cumulative bottle consumption at any time within the next 13 weeks > the current QOH

Recommended Forecasting Methods

Current Forecasting Method

Simple Moving Average (SMA) takes the average of the run rate of

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Proposed LP Model

- Simplified run rate optimization problem
- Adjust run rate only for a part type that has the largest expected photoresist consumption
- Built on Python for a more efficient generation of a run rate

Python 1	Python 2				5					
Material Description RESIST, AIM6023JN-8,B RESIST, AIM9310JN, BO RESIST, AIM9997JN-8,B RESIST, ARX3639JN, BO RESIST, IX238H-6CP, BO	14	15 Week	16 1.00 12.00 12.00	17 1	Materi., Materia RESIST., 160-00.	816A 816C 817A 827A 827B	StpNm WkStn 3010-42 CONTAC 10-PH. T PHOTO 3020-42 CONTAC 10-PH. T PHOTO 3010-42 CONTAC 10-PH. CONTAC 10-PH. T PHOTO 3010-42 CONTAC 10-PH. CONTAC 10-PH. T PHOTO 3010-42 CONTAC 10-PH. T PHOTO T PHOTO T PHOTO T PHOTO	WkStn, Receivi, Receivi, Receivi, Receivi,	Week 15 14 15 0.0004737 0.0004737 50 50 0.004 0.004 0.004737 0.0004737 0.004737 0.0004737 0.0004737 0.0004737 0.612 0.608 0.0004737 0.0004737 950 950 0.0003841 0.0003841 4.300 4.300 0.0003841 0.0003841 0.0003841 0.0003841 2.500 2.500 0.502 0.755	7 8 9 10 11 12 12 12 12 13 14 15 15 15 15 15 15 18 19 19 10 12 12 12 12 12 12 12 12 12 12 12 12 12
RESIST, SEPR772-2.5CP, RESIST, TARF-PI6-144 ME 1.41CP, BOT, 1GAL					RESIST., 160-01.	816A 827A	3010-43 PERIPH 10-PH. PHOTO 3010-43 PERIPH 10-PH. PHOTO	Receivi.	0.0005270 0.0005270 50 50 0.000 0.000 0.0005270 0.0005270 Week:	22 23 24 25 14
RESIST, TOUR-P802, BOT	21.00 Excess 22.00	22.00	24.00 Excess 46.00	46.00		104A 1058 1068	3010-41 BITCON 10-PH. PHOTO 3010-41 BITCON 10-PH. PHOTO 3010-41 10-PH	Receivi. Receivi. Receivi.	WkStni Material Description WeStn Status: DID: StpNm: Material: Bottles Used: bottles Used:	10-PHOTO_ALIGN_193NM RESIST_AIM9310JN_BOT,1 Receiving 827A 3010-43 PERIPH PHOTO 160-01045 0.599

Theoretical LP Model

- Adjusts run rate across all workstation pairs to resolve anticipated excess or shortage of photoresist inventory.
- Able to consider all part types and associated step names simultaneously **Objective** Function:

Limitation

Impractical due to the high dynamicity of manufacturing process



For a particular photoresist, l experiencing a Shortage within the next 13 work weeks:

For a particular photoresist, l experiencing an Excess in week m* when a particular batch of

bottles reach expiry, E1m*:

 $\operatorname{MIN}\left(E_{lm^*} - \sum_{i=1}^{11}\sum_{j=1}^{7}\sum_{k=1}^{4}\sum_{m=1}^{m^*}C_{ijklm} * T_{im} * X_{ijklm}\right) \text{ for the relevant photoresist l, expiry week } m^*$

Example of Final Output

Weeks Left: 3 Material Description: RESIST, TDUR-P802, BOT, 1GAL Part Type: B16C Step Name: 3010-14 STAIRCASE PHOTO Worktation: 10-PHOTO_ALIGN_248NM Adj runrate: 100.0 Remaining Bottles: 8.308514450655217

Ideal Output

Remaining Bottles = 0 (Photoresist's Quantity on Hand – Total **Photoresist Consumption**)

Proposed Methods:

Exponential Moving Average $Y_{t} = \alpha X_{t-1} + (1 - \alpha) Y_{t-1}, \ 0 < \alpha < 1$

Advantages:

- Optimal α can be automatically determined using Python
- Only requires data of the week





the last 5 weeks

Weakness:

Does not reflect the greater relevance of the more recent data by assigning them a higher weightage in the average

2 Weighted Moving Average

 $Y_{t} = W_{1}X_{t-1} + W_{2}X_{t-2} + W_{3}X_{t-3} + W_{4}X_{t-4} + W_{5}X_{t-5},$ $W_1 + W_2 + W_3 + W_4 + W_5 = 1$

Advantages:

prior to forecast

- Works with any number of data available
- Simple to implement •

Further Improvements

- Integrate the python solution method into Tableau using Tabpy to minimize manual exporting and importing of data
- Tracking signal can be improved to flag out whether consistent bias in forecasting is an underlying issue with forecasting method or a capacity problem of the workstation

******* Key Skills Sets

- Data Visualization using Tableau
- Data Cleaning & Analysis using SQL, Python, Excel
- **Statistical Learning**
- Linear Programming
- Project Management



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Conclusion

Reduced communication inefficiency: Centralised data platform on Tableau -> close down information gap



Increase the adaptability in workstation loading:

LP model on Python -> generates new loading percentage (run rate) in real time



What's Next:

Extend the proposed methodology to other fabrication plants