

Wafer Defect Analysis Report

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Executive Summary

The report presents findings from analyzing inspection data collected from semiconductor manufacturing operations. We cleaned and prepared data from more than 25,000+ wafer inspections before studying essential quality metrics. The analysis reveals the following key findings:

- An overall failure rate of **41.9%** and average defects of **2.95 per wafer**
- A monthly failure rate stable around **42%**, with a peak of **44%** in July 2024 and a dip to **40%** in May 2025
- Tools **DUV-2100** and **ETCH-V9** showing the highest failure rates (43% and 42%) and defect counts
- Batches **BAT022**, **BAT004**, and **BAT008** having the worst performance (44% failure)
- **Particle contamination** and **overlay misalignment** as the top defect types, accounting for **62%** of all failures

The proposed recommendations emphasize contamination control and tool maintenance for DUV-2100 and root cause analysis for high-failure batches.

1. Introduction

The semiconductor wafer production process includes various steps which create potential defects. The monitoring of wafer quality stands as a vital factor for achieving both high yield rates and customer satisfaction. The project demonstrates how a data analyst would work with a simulated realistic dataset through three steps: data inspection cleaning followed by quality metric calculation and dashboard creation with actionable insights.

Project Goal: The project aims to deliver a quick overview of wafer quality while pinpointing the primary areas that need improvement in a semiconductor fabrication plant.

2. Data & Methodology

2.1 Data Description

- **Source:** Simulated wafer inspection records (25,000+ rows)
- **Key columns:** wafer_id, batch_id, tool_id, defect_type, defect_count, inspection_result (Pass/Fail), inspection_date

2.2 Data Cleaning Highlights

- Removed or flagged rows with missing wafer IDs, tool IDs, defect counts, and dates
- Corrected logical errors: 113 rows with no defect but marked Fail were set to Pass with defect_count = 0
- Excluded outliers: defect counts above 50 were flagged and removed from analysis
- Excluded rows with invalid dates (error_date)
- Ensured no duplicate rows remained

A final `cleaned_data` sheet contains only valid, analysis-ready records.

3. Key Performance Indicators (KPIs)

Metric	Value
Total Inspections	24,697
Pass Rate	58.1%
Fail Rate	41.9%
Average Defect Count per Wafer	2.95
Max Defect Count (Sanity)	50
Top Defect Type	Particle contamination (4,999)

These KPIs provide a quick overview of overall process quality.

4. Monthly Trend Analysis

A line chart of monthly failure rates shows:

- **July 2024:** Highest failure rate at 44%
 - **May 2025:** Lowest failure rate at 40%
 - Overall trend stable around 42%
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5. Tool Performance

5.1 Failure Rate by Tool

Tool ID	Failure Rate
DUV-2100	43.0%
ETCH-V9	42.0%
CVD-Z5	42.0%
CMP-X7	41.9%
EUV-3000	41.0%

DUV-2100 shows the highest failure rate and should be reviewed for calibration and maintenance.

5.2 Average Defects by Tool

Tool ID	Avg Defects
DUV-2100	3.00
ETCH-V9	2.98
CVD-Z5	2.95
CMP-X7	2.91
EUV-3000	2.88

High defect counts on *DUV-2100* and *ETCH-V9* align with their failure rates.

6. Batch Performance

Top 10 batches by failure rate:

Batch ID	Failures	Passes	Failure Rate
BAT022	352	440	44.0%
BAT004	339	425	44.0%
BAT008	350	442	44.0%
BAT012	369	470	44.0%
BAT006	362	467	44.0%
BAT011	353	464	43.0%
BAT015	344	455	43.0%
BAT007	349	462	43.0%
BAT017	350	464	43.0%
BAT010	351	467	43.0%

These batches may have had local process issues or material variability and warrant further root cause analysis.

7. Defect Type Analysis

Defect Type	Fail Count
Particle contamination	3,825
Overlay misalignment	2,873
Etch residue	1,497
Scratches	1,230
Photoresist peeling	922

Particle contamination and overlay misalignment account for nearly 62% of all failures, indicating a strong need to improve cleanroom controls and overlay accuracy.

8. Business Recommendations

1. **Contamination Control:** Enhance cleanroom protocols and filter maintenance to reduce particle contamination.
 2. **Tool Maintenance:** Schedule detailed calibration and preventive maintenance for DUV-2100 and ETCH-V9.
 3. **Batch Process Review:** Investigate high-failure batches (e.g., BAT022) for process deviations, material lots, or operator practices.
 4. **Alignment Procedures:** Review overlay alignment procedures and tool settings to lower misalignment defects.
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Appendix

- Detailed cleaning log and intermediate flag columns are available in the `Cleaning_Log` sheet.
- All PivotTables and charts used for analysis are on separate sheets for transparency.