The Waferstepper Challenge: Innovation and Reliability despite Complexity

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Abstract

The function of the waferstepper is explained and its most important characteristics. The dynamic market provides continuous technological challenges, resulting in ever increasing performance, but also complexity. Despite the exponential increase of performance and complexity, the reliability must be good. The reliability is crucial when the stepper is used in volume production. The ASML engineering style plays a central role in tackling this challenge. Three key aspects of this style are: Feedback, Focus and Future awareness. The concurrent application of these three aspects has so far been proven to be effective.
What is a waferstepper

source
reticle
lens
wafer
From stepping to scanning

**stepper:** static exposure of field

**scanner:** dynamic exposure through slit
Key specifications waferstepper

imaging

alignment

130 nm

10 nm line width

critical dimension

45 nm overlay

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September 3, 2020
ASMLkeySpecifications
Moore’s law
Overlay budget (1999)

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ASMLOverlayBudget
Everything influences overlay
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ASMLproblemIRC
The Software Reliability Threat

Based on average 3 errors/kloc

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ASMLproblem
Success factor: ASML system engineering style

feedback
budget & measure
focus
keydrivers
future
roadmaps

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ASML style SE
Feedback as technical design pattern

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ASML.feedbackWS

**Feedback frequency:**
4 kHz (250 usec)

**Feedback:** fast and accurate

**Wireframe Diagram:**
- **waferstage**
- **interferometers**
- **level sensor**
- **actuators**

**Mathematical Equations:**
\[ v = 250 \text{mm/s} \]
\[ a = 10 \text{m/s}^2 \]
Feedback as development process pattern

- **Stepsize:** 3 months
- **Elapsed time:** 25 months

Diagram showing the development process pattern with a target and a start point.
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Small feedback cycles result in Faster Time to Market
MTBF as function of time

- MTBF in hours
- Time after first installation
  - 0 year
  - 1 year
  - 2 years

- New variant
- New generation
Focus via key drivers

Mission statement

Value of Ownership

Cost per function

Customer satisfaction

Critical Dimension

Overlay

Productivity

Product added value

First year's shipment
Productivity decomposed

Productivity

- throughput
- yield
- stepper costs
- uptime / maintenance
- installation time
- economic lifetime

scheduled maintenance

- minimize unscheduled downtime
  - MTBF
  - MTTR
ASML System Engineering style

feedback
future aware
focus

imaging
innovation
overlay

complexity

reliability
The case material is based on actual data, from a complex context with large commercial interests. The material is simplified to increase the accessibility, while at the same time small changes have been made to remove commercial sensitivity. Commercial sensitivity is further reduced by using relatively old data (between 5 and 10 years in the past). Care has been taken that the illustrative value is maintained.