Improvisation as second nature: EMC testing at ASML

Tim Maas

Competence leader EMC

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ASML in 34 years

1984

Total market: €463 million
Employees: <60
Locations 2 (NL, USA)
Revenue: <€ 1.2 million
Profit: nil
R&D cost: € <5 million

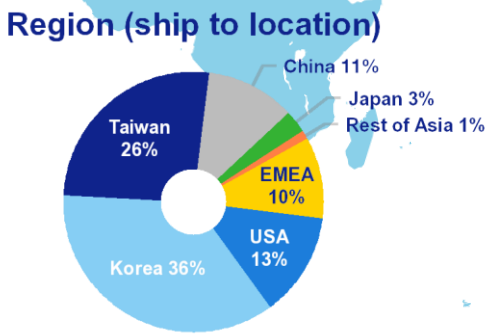
34

2018

Total market: € 10 - 11 billion
Employees: > 20.000
Locations: 70 in 16 countries
Revenue: € 9.1 billion (2017)
Profit: € 2.1 billion (2017)
R&D cost: >€ 1.3 billion (2017)
of which 75% in the Netherlands

ASML in 34 years

UK
Ireland
Netherlands
Germany
US
Belgium
Israel
France
Italy
China
Korea
Japan
Hong Kong
Malaysia
Taiwan
Singapore

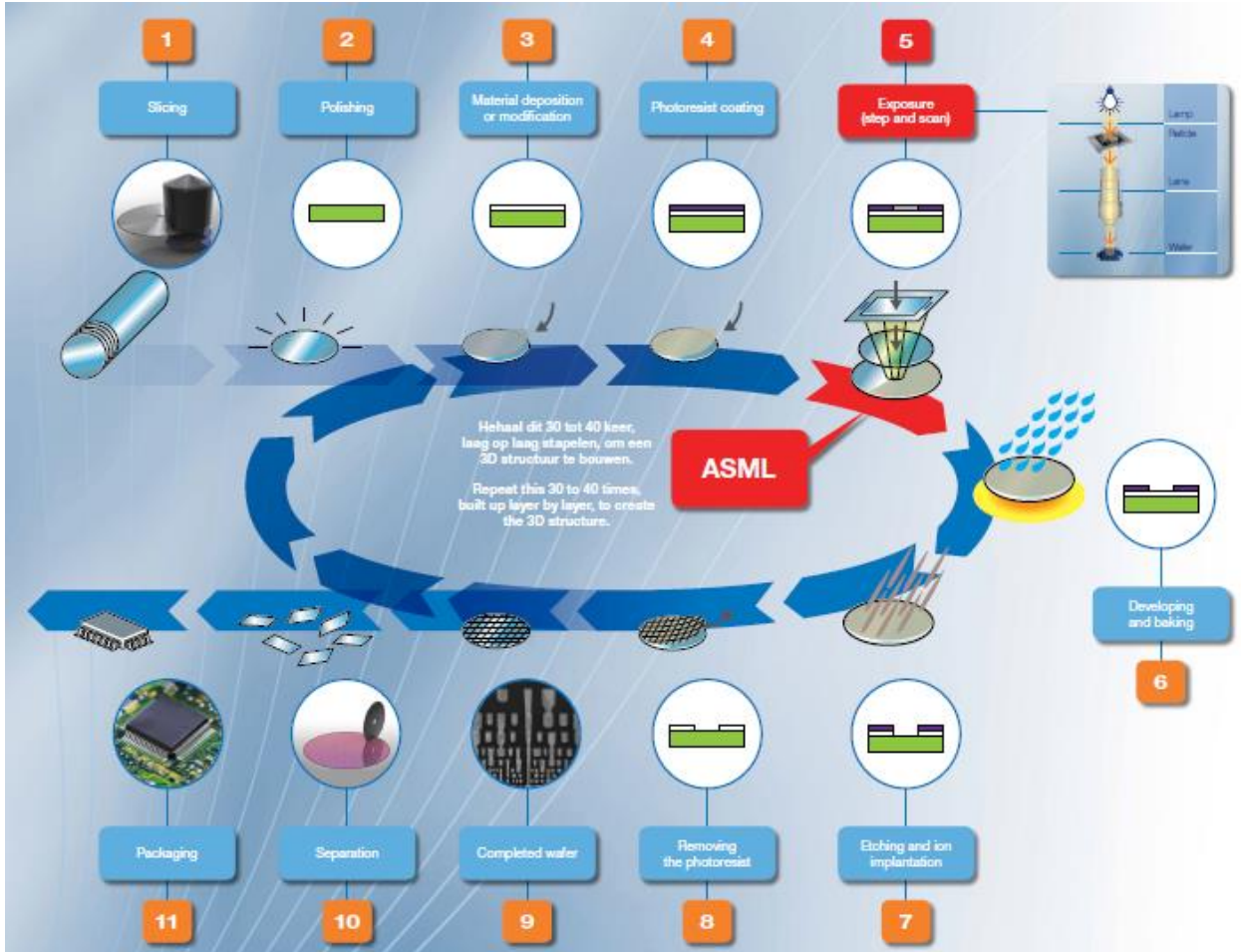


More than 60 locations in 16 countries

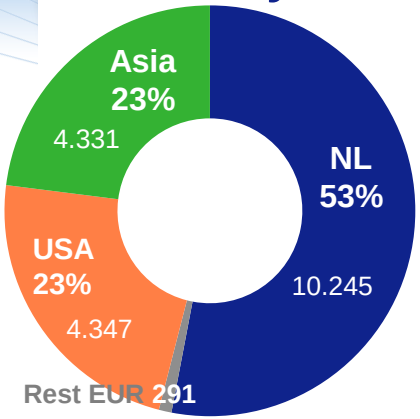
Source: ASML Q4 2017

EMEA = Europe, Middle East and Africa

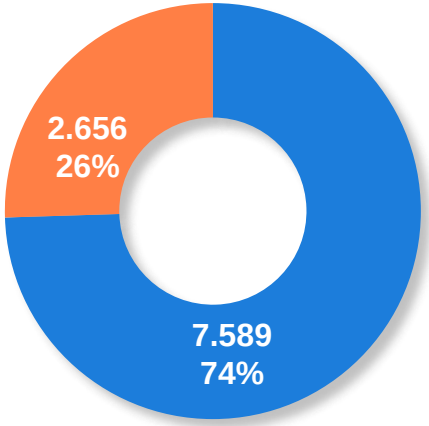
Lithography is the heart of chip production



Diversity at ASML



Worldwide 19.215



The Netherlands 10.245

Employees

Fix **Flex**

End 2017 (FTE)

Top 10 in Veldhoven

1 Netherlands (7.779)
2 Belgium (408)
3 India (232)
4 China (182)
5 Italy (124)
6 Ireland (120)
7 Greece (111)
8 Germany and Turkey (96)
9 Poland and Spain (91)
10 United Kingdom (77)

ASML

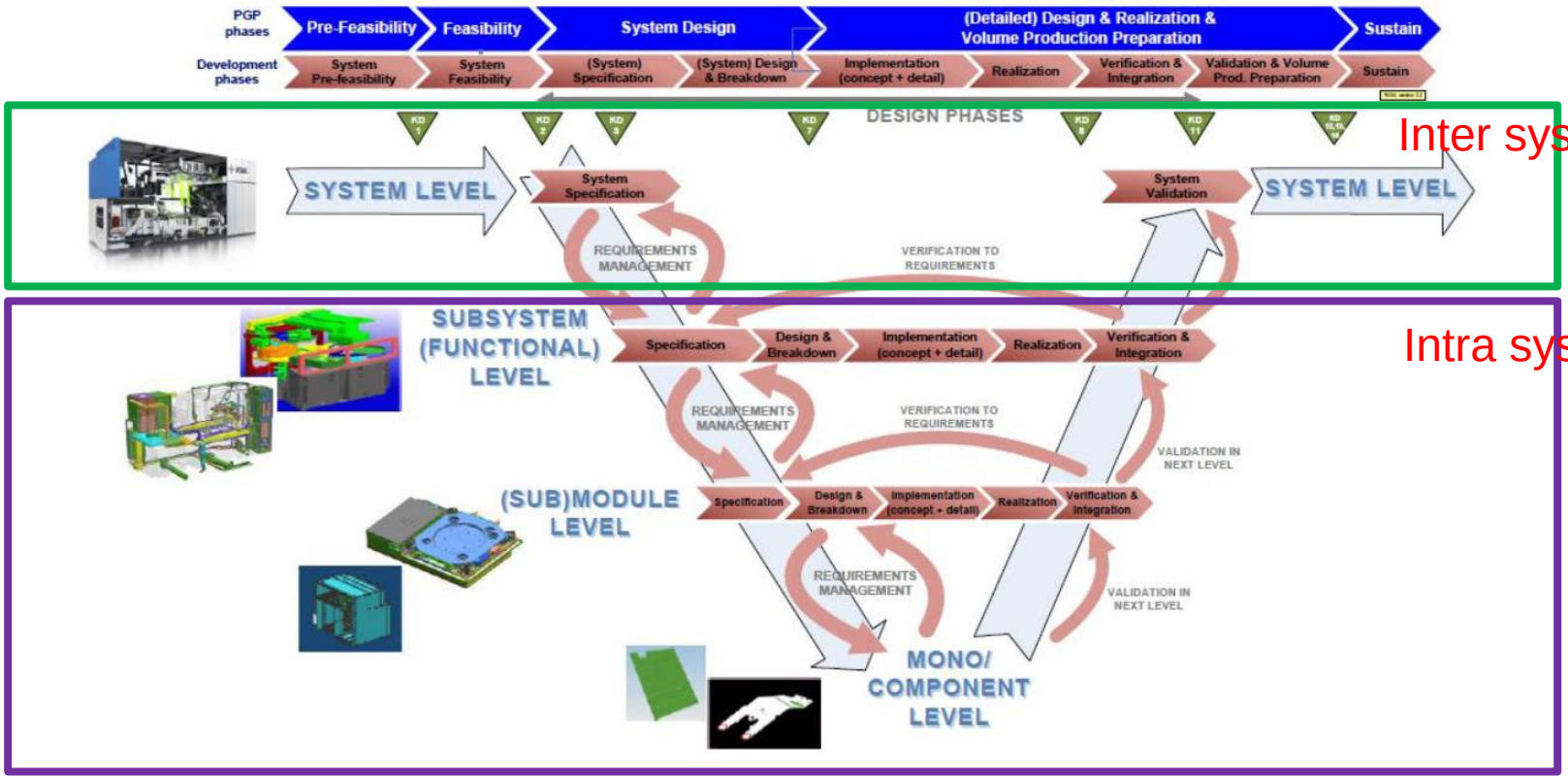
- 115 nationalities ww
- 93 nationaliteiten in Veldhoven
- 24% non-Dutch in Veldhoven
- 33% Bachelors degree
- 49% Masters degree
- > 800 PhDs
- 8 part-time profs at NL universities
- 14% female

…all this while become (or remain) CE/ FCC compliant!

And do this fast, cheap AND right the first time!

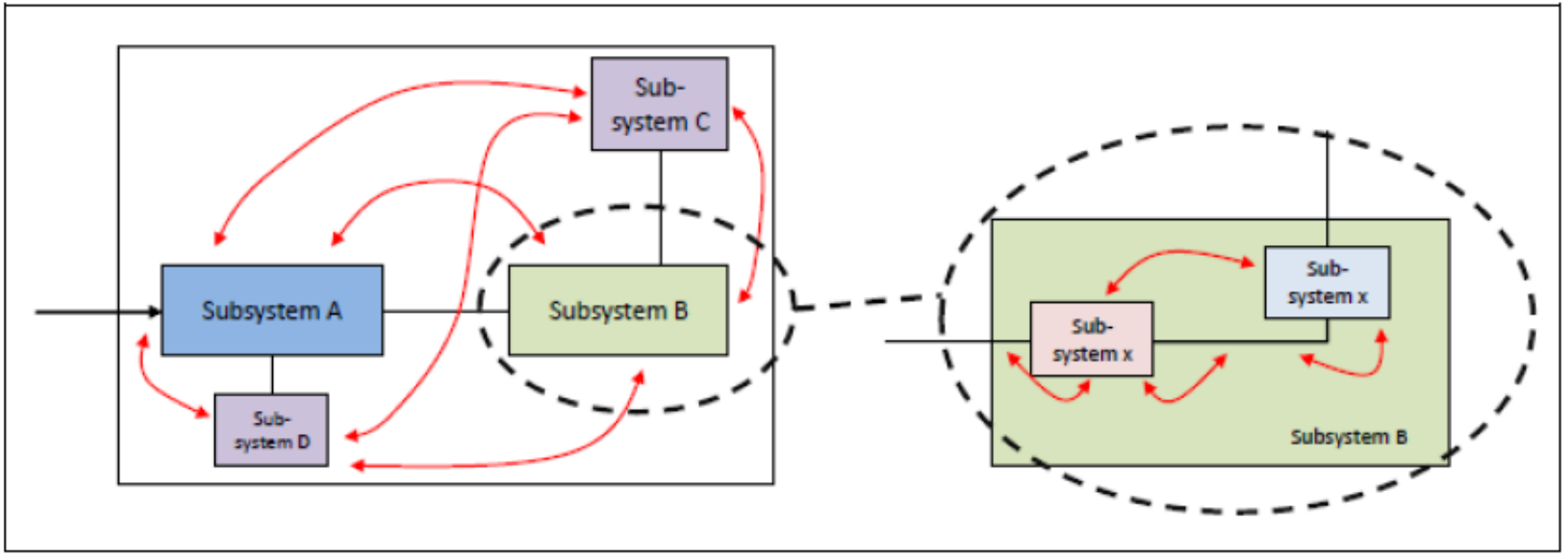
EMC compliance and ASML → How to?

Synchronize with the design flow



EMC compliance and ASML → How to?

Perform EMC risk assessment



System A

System B

EMC compliance and ASML → How to?

Point score determines the risk and thus focus of testing

Phenomena		Effect on system level or environment	Probability of occurrence (intended/unintended)		
Conducted emission			Unlikely	Possible	Likely
Radiated emission		insignificant	1	2	3
		minor	2	3	4
		significant	3	4	5
		major	4	5	6
	fill-in	***Sub-result***	0	4	0
	fill-in	Noise source	0	2	0
		Final Result	0	8	0

multiply

Noise source	
(0.5): Low	Complies with the emission levels (-6dB margin)
(1): Medium	Complies with the emission levels (no margin)
(2): Unknown	Emission level is unknown
(3): High	Emission levels exceed system limits

Final Result		
0.5 - 4	Low	Acceptable risk; no action needed.
5 - 9	Medium	Further investigation is necessary to determine OK/NOK and respective actions
10 - 18	High	Take measures to minimize the risk, needs immediate attention.

Figure 13 Matrix for Conducted Emissions

EMC compliance and ASML → How to?

Anyone able to fit this in his/ her “clean room compatible” FAR/ SAR?

Brion Tachyon
Computing platform

ASML NXT2000i scanner

ASML PAS 5500 D Wafer stepper

System dimensions & dangers

Power, water, gas requirements

- Up to 1,5 MW of consumed power for our largest systems

  (Some modules require up to 300+ A per phase (@400 V)

- (Cooling) water of various temperatures and electrical conductivity

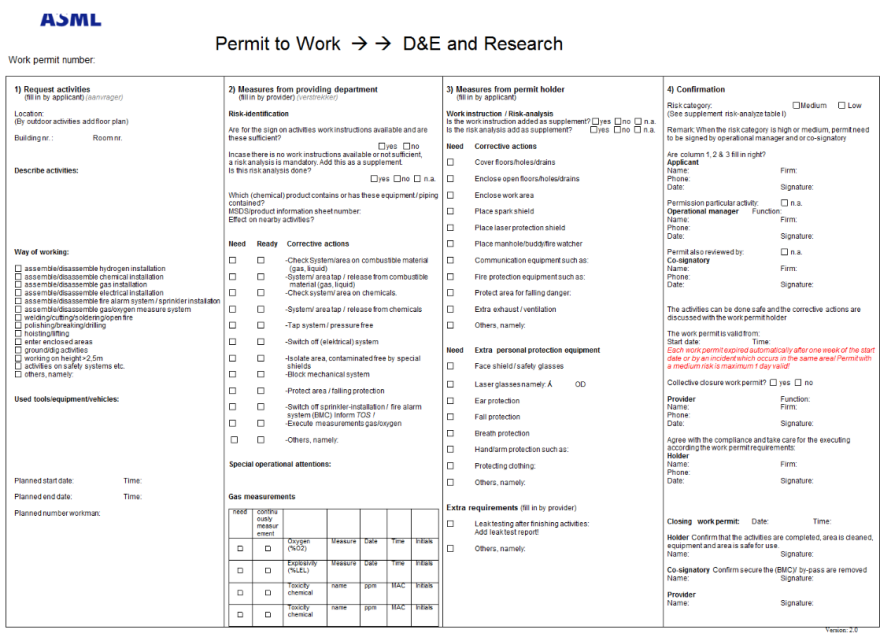
- Gas requirements:
  - CDA , XCDA, XCHA
  - H_2, N_2, CO_2, F_2, Ar, He, Kr




(X)CDA = (extreme) Clean Dry Air XCHA = Extreme Clean Humidified Air

EMC testing at ASML: Safety first!!!

Work permit



ASML

Permit to Work → → D&E and Research

Work permit number:

1) Request activities (fill in by applicant) *(aanvrager)*

Location: (By outdoor activities add floor plan)

Building nr.: Room nr.

Describe activities:

Way of working:

- ☐ assemble/disassemble hydrogen installation
- ☐ assemble/disassemble chemical installation
- ☐ assemble/disassemble gas installation
- ☐ assemble/disassemble electrical installation
- ☐ assemble/disassemble fire alarm system / sprinkler installation
- ☐ assemble/disassemble gas/oxygen measure system
- ☐ welding/cutting/soldering/open fire
- ☐ polishing/breaking/drilling
- ☐ hoisting/lifting
- ☐ enter enclosed areas
- ☐ ground/dig activities
- ☐ working on height >2,5m
- ☐ activities on safety systems etc.
- ☐ others, namely:

Used tools/equipment/vehicles:

Planned start date: Time:

Planned end date: Time:

Planned number workman:

2) Measures from providing department (fill in by provider) *(verstrekker)*

Risk-identification

Are for the sign on activities work instructions available and are these sufficient? ☐yes ☐no

Incase there is no work instructions available or not sufficient, a risk analysis is mandatory. Add this as a supplement.
Is this risk analysis done? ☐yes ☐no ☐ n.a.

Which (chemical) product contains or has these equipment / piping contained?
MSDS/product information sheet number:
Effect on nearby activities?

Need	Ready	Corrective actions
☐	☐	-Check System/area on combustible material (gas, liquid)
☐	☐	-System/ area tap / release from combustible material (gas, liquid)
☐	☐	-Check system/ area on chemicals.
☐	☐	-System/ area tap / release from chemicals
☐	☐	-Tap system / pressure free
☐	☐	-Switch off (elektrical) system
☐	☐	-Isolate area, contaminated free by special shields -Block mechanical system
☐	☐	-Protect area / falling protection
☐	☐	-Switch off sprinkler-installation / fire alarm system (BMC) inform TCS / -Execute measurements gas/oxygen
☐	☐	-Others, namely:

Special operational attentions:

Gas measurements

need	continuously measurement						
☐	☐	Oxygen (%02)	Measure	Date	Time	Initials
☐	☐	Explosivity (%LEL)	Measure	Date	Time	Initials
☐	☐	Toxicity chemical	name	ppm	MAC	Initials
☐	☐	Toxicity chemical	name	ppm	MAC	Initials

3) Measures from permit holder (fill in by applicant)

Work instruction / Risk-analysis
Is the work instruction added as supplement? ☐yes ☐no ☐ n.a.
Is the risk analysis add as supplement? ☐yes ☐no ☐ n.a.

Need	Corrective actions
☐	Cover floors/holes/drains
☐	Enclose open floors/holes/drains
☐	Enclose work area
☐	Place spark shield
☐	Place laser protection shield
☐	Place manhole/buddy/fire watcher
☐	Communication equipment such as:
☐	Fire protection equipment such as:
☐	Protect area for falling danger.
☐	Extra exhaust / ventilation
☐	Others, namely:

Need	Extra personal protection equipment
☐	Face shield / safety glasses
☐	Laser glasses namely: A OD
☐	Ear protection
☐	Fall protection
☐	Breath protection
☐	Hand/arm protection such as:
☐	Protecting clothing:
☐	Others, namely:

Extra requirements (fill in by provider)

- ☐ Leak testing after finishing activities: Add leak test report!
- ☐ Others, namely:

4) Confirmation

Risk category: ☐Medium ☐ Low
(See supplement risk-analyze table I)

Remark: When the risk category is high or medium, permit need to be signed by operational manager and or co-signatory

Are column 1, 2 & 3 fill in right?
Applicant
Name: Firm:
Phone:
Date: Signature:

Permission particular activity: ☐ n.a.
Operational manager Function:
Name: Firm:
Phone:
Date: Signature:

Permit also reviewed by: ☐ n.a.
Co-signatory
Name: Firm:
Phone:
Date: Signature:

The activities can be done safe and the corrective actions are discussed with the work permit holder

The work permit is valid from:
Start date: Time:
Each work permit expired automatically after one week of the start date or by an incident which occurs in the same area! Permit with a medium risk is maximum 1 day valid!

Collective closure work permit? ☐ yes ☐ no

Provider Function:
Name: Firm:
Phone:
Date: Signature:

Agree with the compliance and take care for the executing according the work permit requirements:
Holder
Name: Firm:
Phone:
Date: Signature:

Closing work permit: Date: Time:

Holder Confirm that the activities are completed, area is cleaned, equipment and area is safe for use.
Name: Signature:

Co-signatory Confirm secure the (BMC)/ by-pass are removed
Name: Signature:

Provider
Name: Signature:

Version: 2.0

Specialist training

- EHS
- High voltage/ Perform LOTO
- Working at Heights
- CO2 gas safety
- Laser safety
- Contamination risks
- Carrying of wafers & Reticles
- Working ESD safe

EMC testing at ASML

Abnormal labor circumstances → Working on heights

- ESD immunity testing on machine top side using safety harness

- ESD immunity testing above 2 m using mobile scaffolding with extended reach

EMC testing at ASML

Abnormal labor circumstances → confined spaces

- Electrical hook up of EMC test equipment in machine mains supply cabinet

- EFT immunity testing in sub-floor space

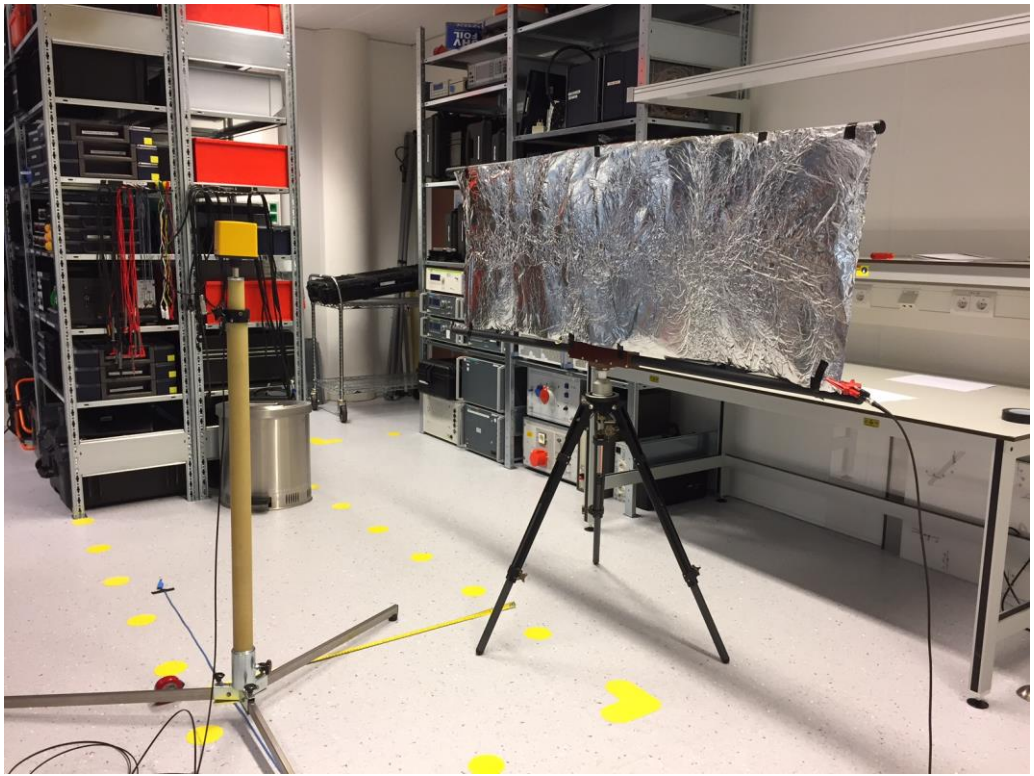
EMC testing at ASML → Customized test tooling

PFMF testing

Magnetic field emission testing

EMC testing at ASML → Customized test tooling

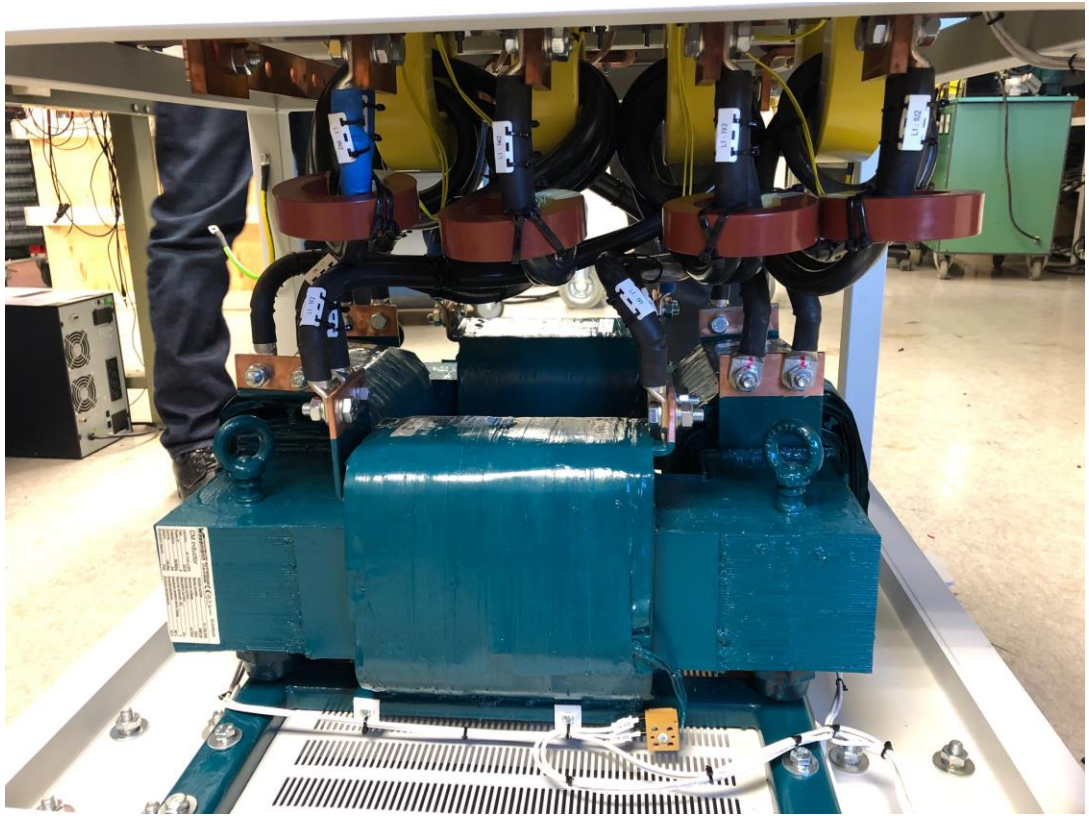
ELF E-field immunity (← SEMI E33 →)



ELF H-field emission

EMC testing at ASML → Customized test tooling

High power/ high current EFT/ Surge/ CE/ CI → 700 A filter



Not just machines → production tooling as well!

The cleanroom “mammoet” vehicle

32 Wheels

20 tonnes payload

1 operator

2 assistants

Wireless operation

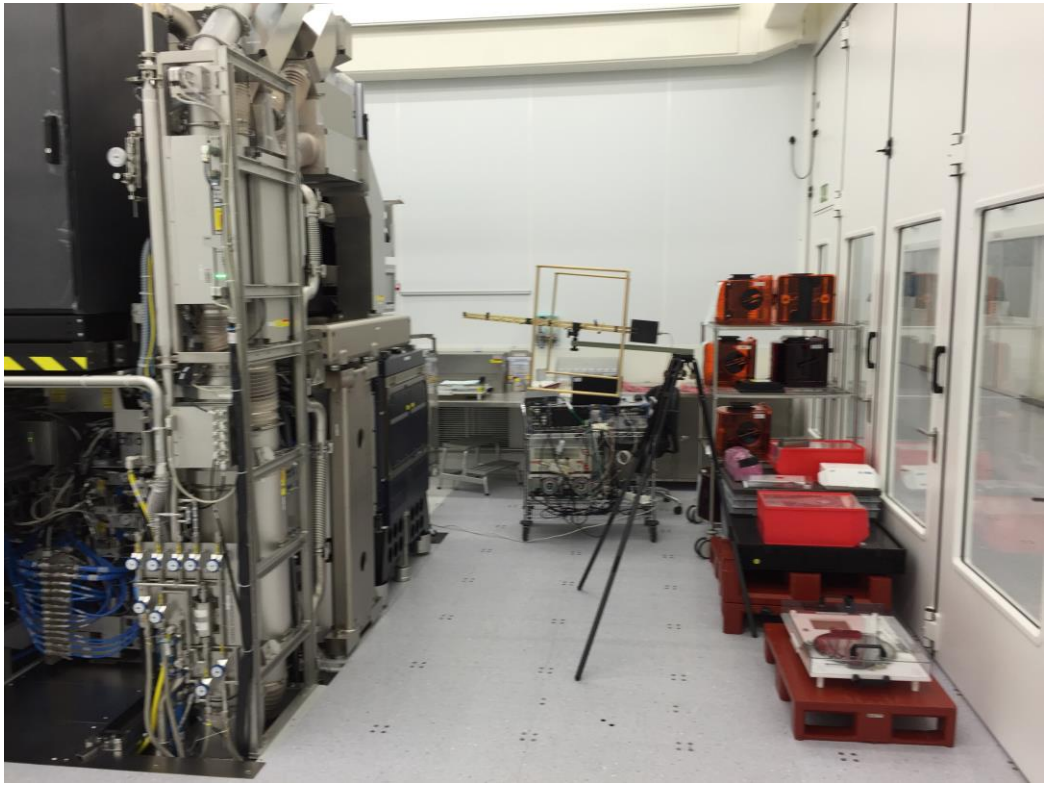
How about the cleanroom itself???

It’s a Faraday cage with RF resonance capabilities

Checking for resonances using the surface current sense wire and a Radisense probe

Environmental contributions

WiFi/ GSM/ Radar/ ERT pagers/ Cranes/ RFID tag reader/ other systems



Each test:

Step 1 Environmental scan

Step 2 EUT + ENV scan

Step 3 Result step 2 – result step 1

Step 4 Final scan

A laborious effort!!!

(and don’t forget your work permit...)

EMC testing at ASML…

Improvisation challenge accepted!!!