Advanced Research Center for Nanolithography

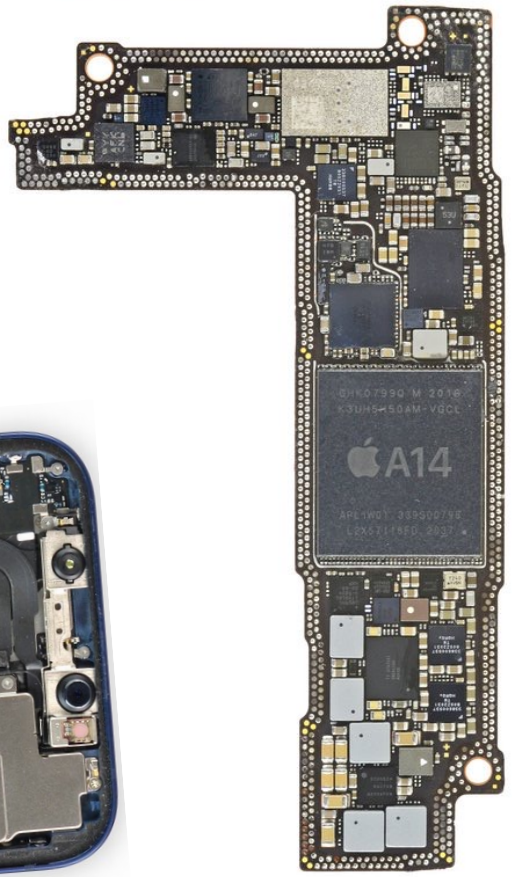
A scientific startup!

- EUV Lithography: what & why
- ARCNL: what, where & how
- Organization, output, …

ARCNL

www.arcnl.nl

iPhone 12 on the inside



contains
1.2×10^{10}
transistors

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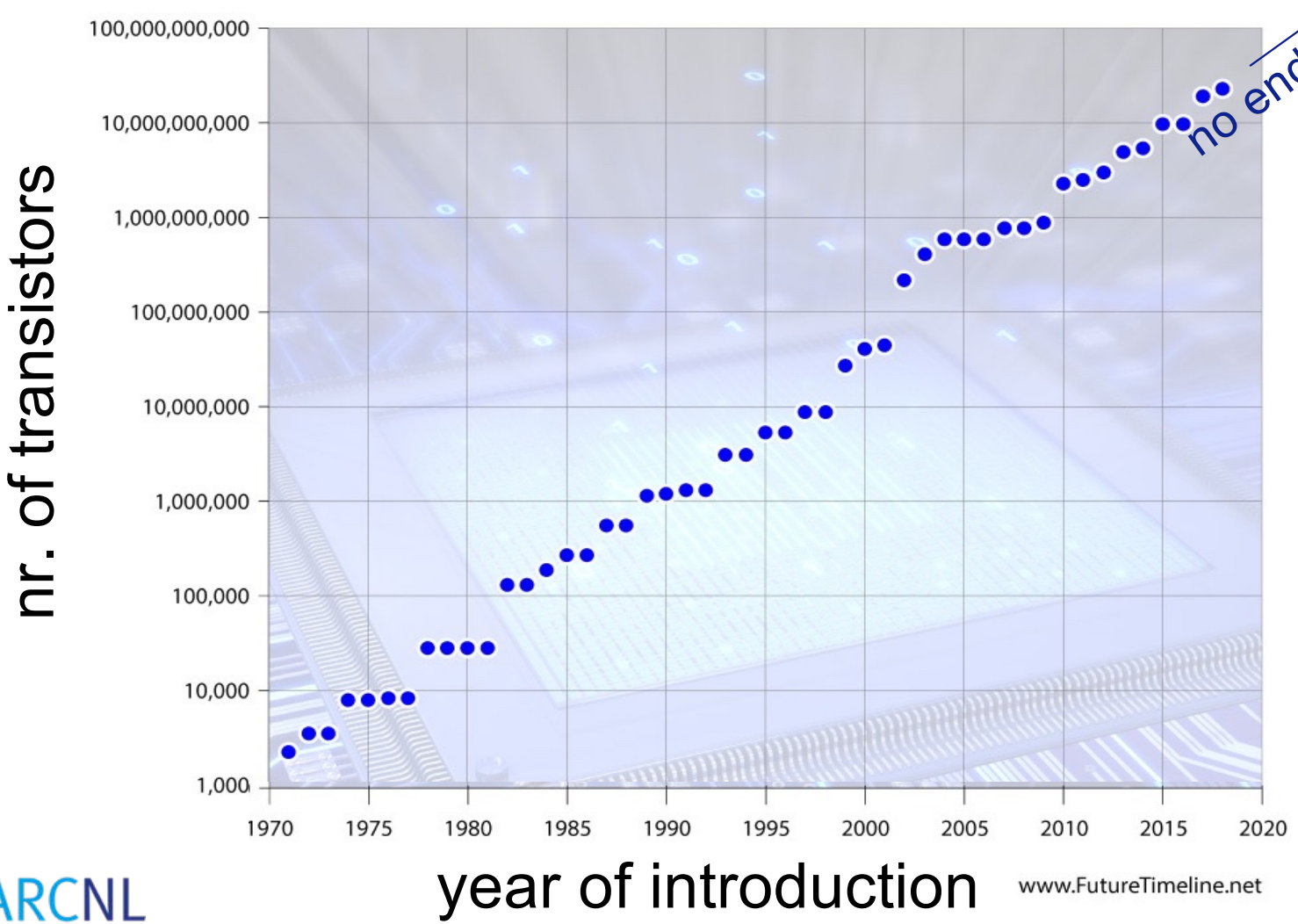
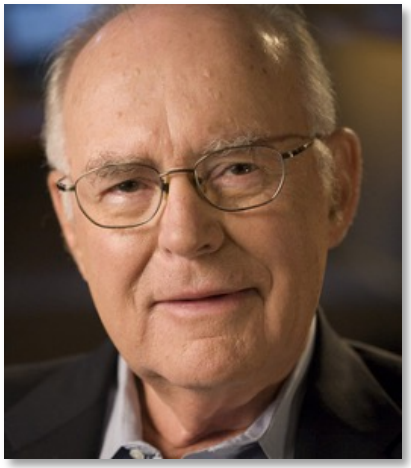
Moore's law (1965)

Latest: 1.2 x 10^{10} transistors in A14 bionic chip (iPhone 12)



Number of transistors in processor chips doubles every two years !!!



Gordon Moore (1975)

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Computer chips on the inside: 3D structures

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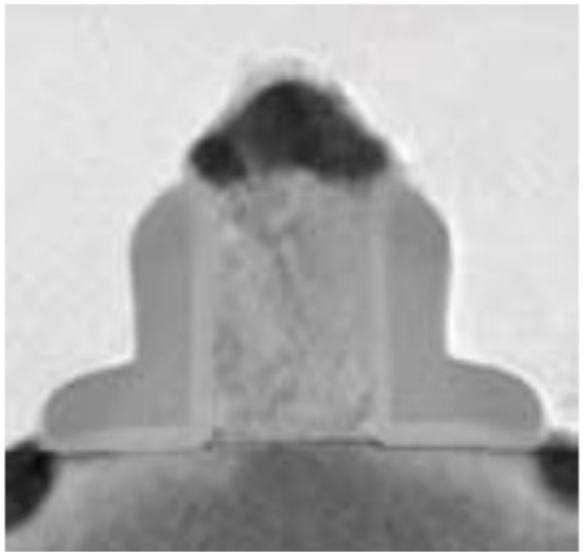
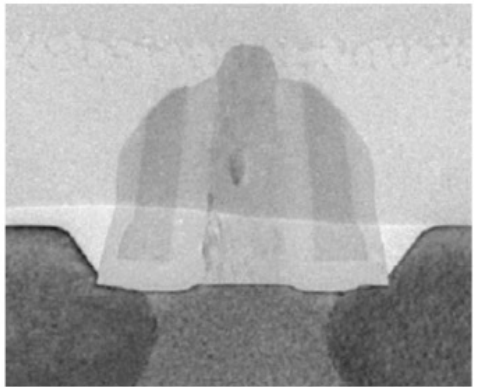
Source: ASML

Moore's law: smaller, smaller, smaller, smaller, smaller, smaller, smaller, smaller, ...

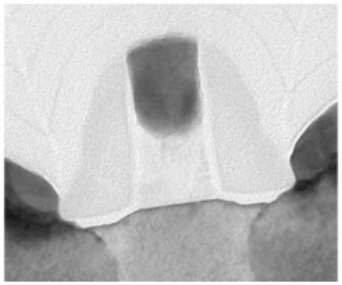
(nano)transistors by intel



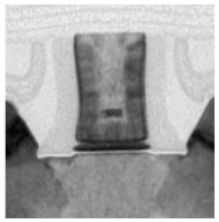
130 nm
2001



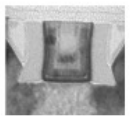
90 nm
2003



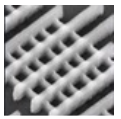
65 nm
2005



45 nm
2007



32 nm
2009



22 nm
2011

14 nm
2014

10 nm
2017

7 nm
2019

we're now at 5 nm!

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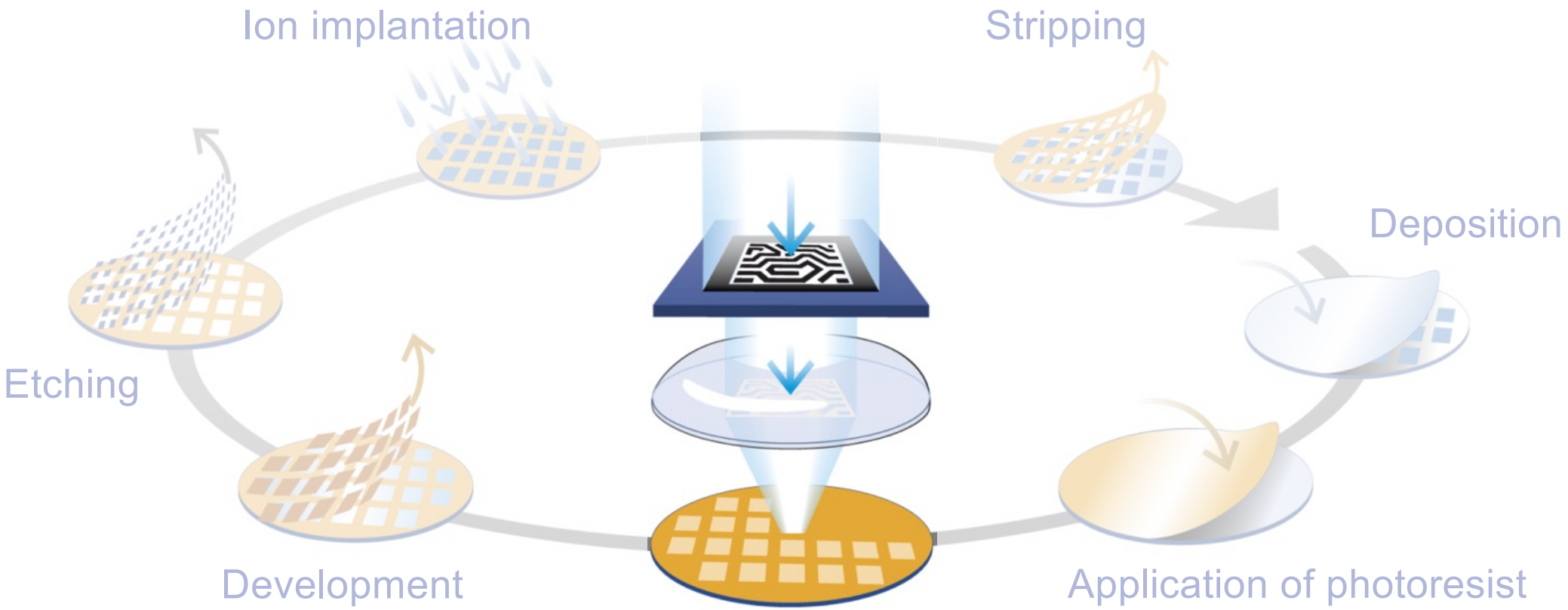
Lithography is the determining step



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Source: ASML

EUV lithography technology

extreme ultraviolet light

λ = 13.5 nm

Source: ASML

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ASML: an interesting ‘startup’

AEX stock value

company started in 1984 by Philips and ASMI

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Advanced Research Center for Nanolithography

Our partners

Universiteit van Amsterdam

VU Vrije Universiteit Amsterdam

ASML

NWO

ARCNL focuses on fundamental physics and chemistry in the context of technologies for (nano)-lithography, primarily for the semiconductor industry

ARCNL

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- Research institute with ~100 researchers, technicians and support staff
- Connected with UvA en VU
- Strong link with ASML

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- VU Vrije Universiteit Amsterdam
- ASML
- NWO

- *Since:* 2014
- *Partners:* NWO, UvA, VU, ASML
  - intimate research relation with AMOLF
  - growing network of collaborations and joint programs
  - accession RUG underway
- *Base funding:* 50% ASML, 50% NWO + UvA + VU
  - rest through grants
- *Style:* NWO-Institute; Dutch Research Council

ARCNL focuses on fundamental physics and chemistry in the context of technologies for (nano)-lithography, primarily for the semiconductor industry

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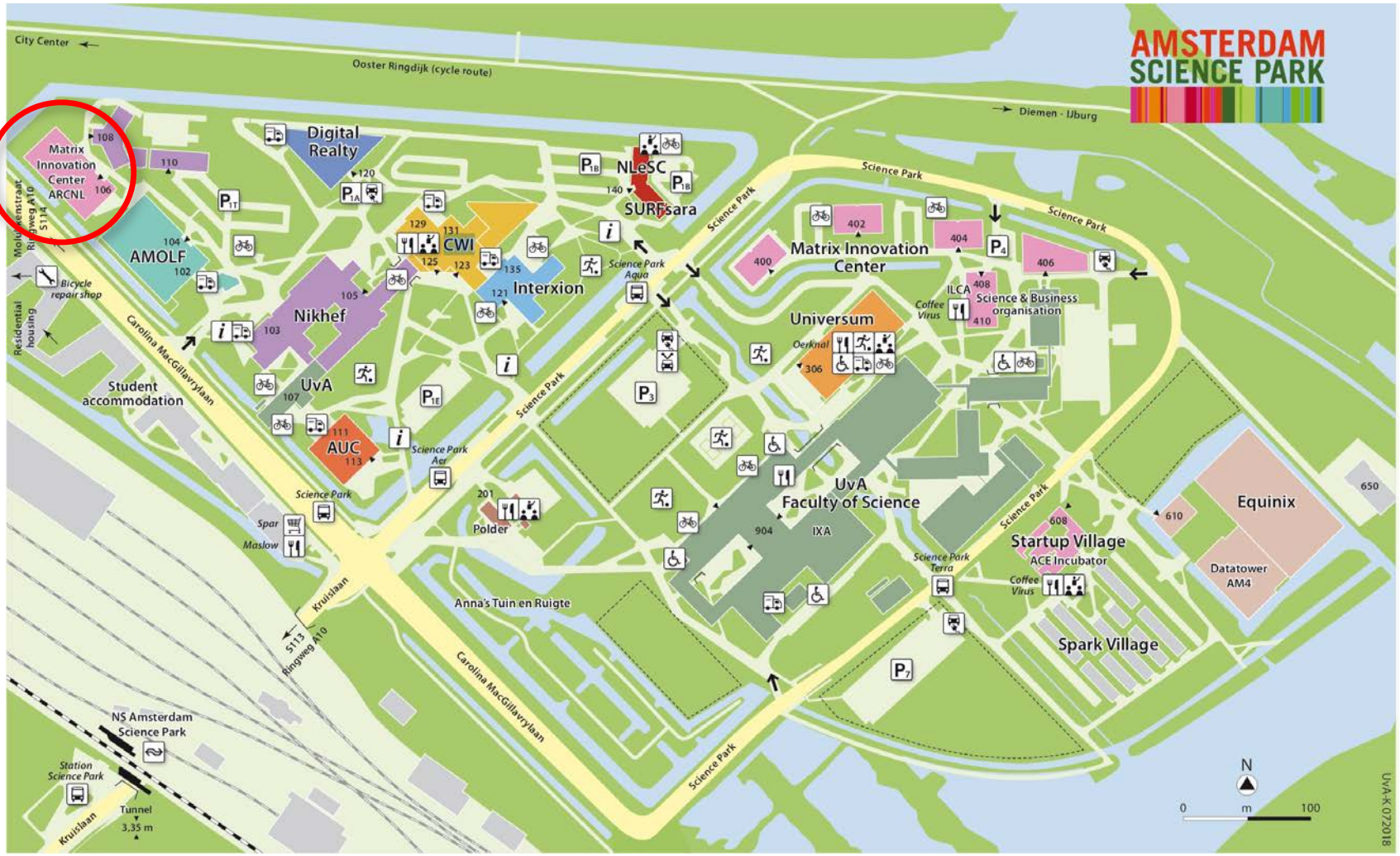
ARCNL's location



Who does the work @ ARCNL?

- *PhD students:* currently 31
- *Postdocs:* currently 14
- *Research interns:* currently 5
- *Senior scientists:* currently 17
- *Group technicians:* currently 7
- *Support staff:* currently ~ 18 (partly @ AMOLF)

Interested?

https://arcnl.nl/working-at-arcnl **https://arcnl.nl/jobs**

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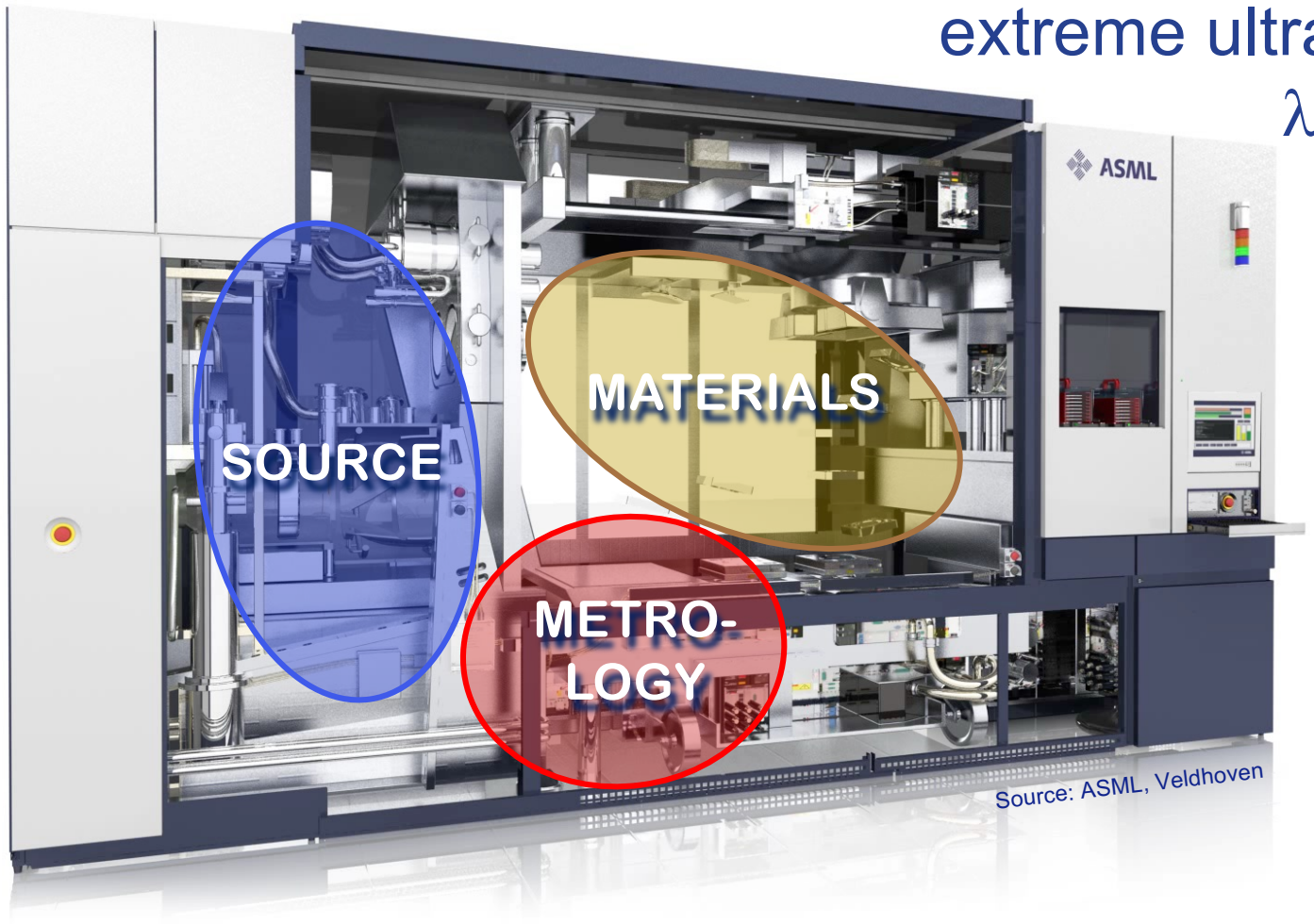
EUV lithography technology

extreme ultraviolet light

λ = 13.5 nm



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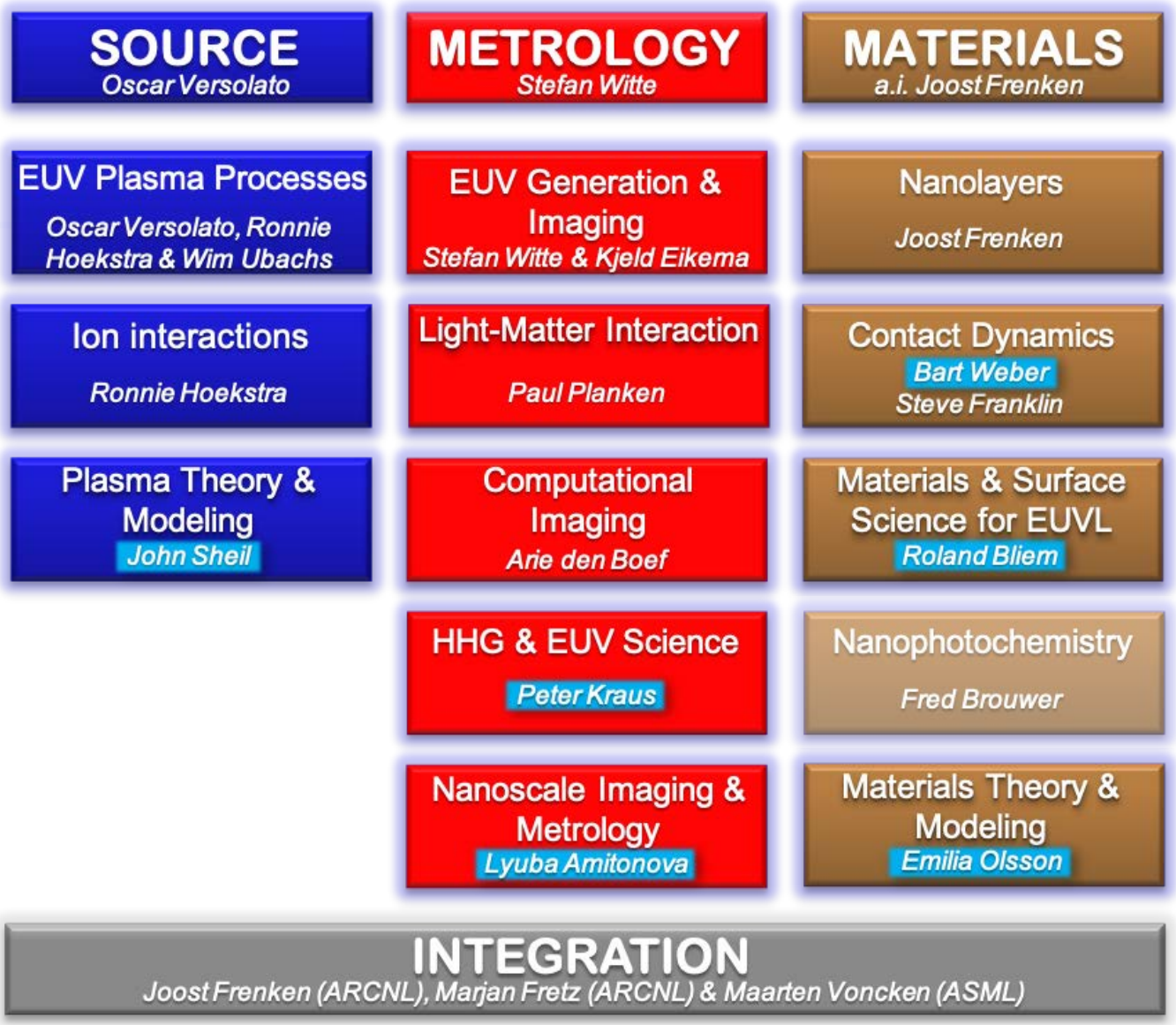
Scientific program

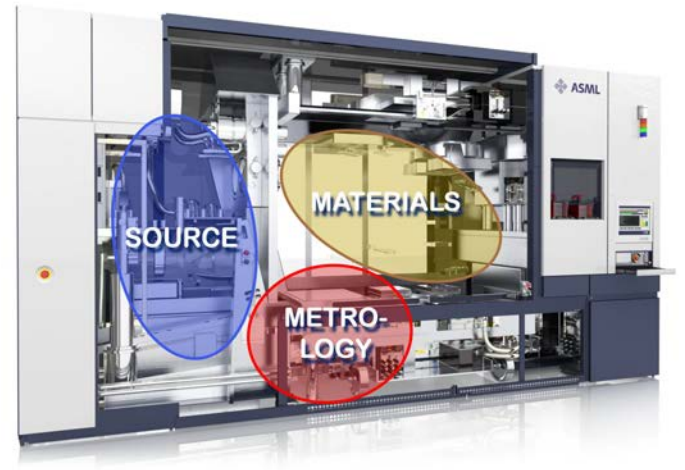
- Three departments:
  13 research groups
  - group leader(s)
  - PhD students, postdocs, interns
  - group technician
- blue = tenure track
- ~ 100 people



ARCNL

What's our research about?

- Everything on generating Extreme Ultraviolet (EUV) light
- Developing new laser systems
- Controling materials on the atomic scale for lenses for that 'difficult' light
- Friction on the atomic scale
- Designing molecules as (EUV) light-sensitive layer
- New ways to look very precisely *in* and *through* materials: for positioning and control of structures with (near) atomic precision



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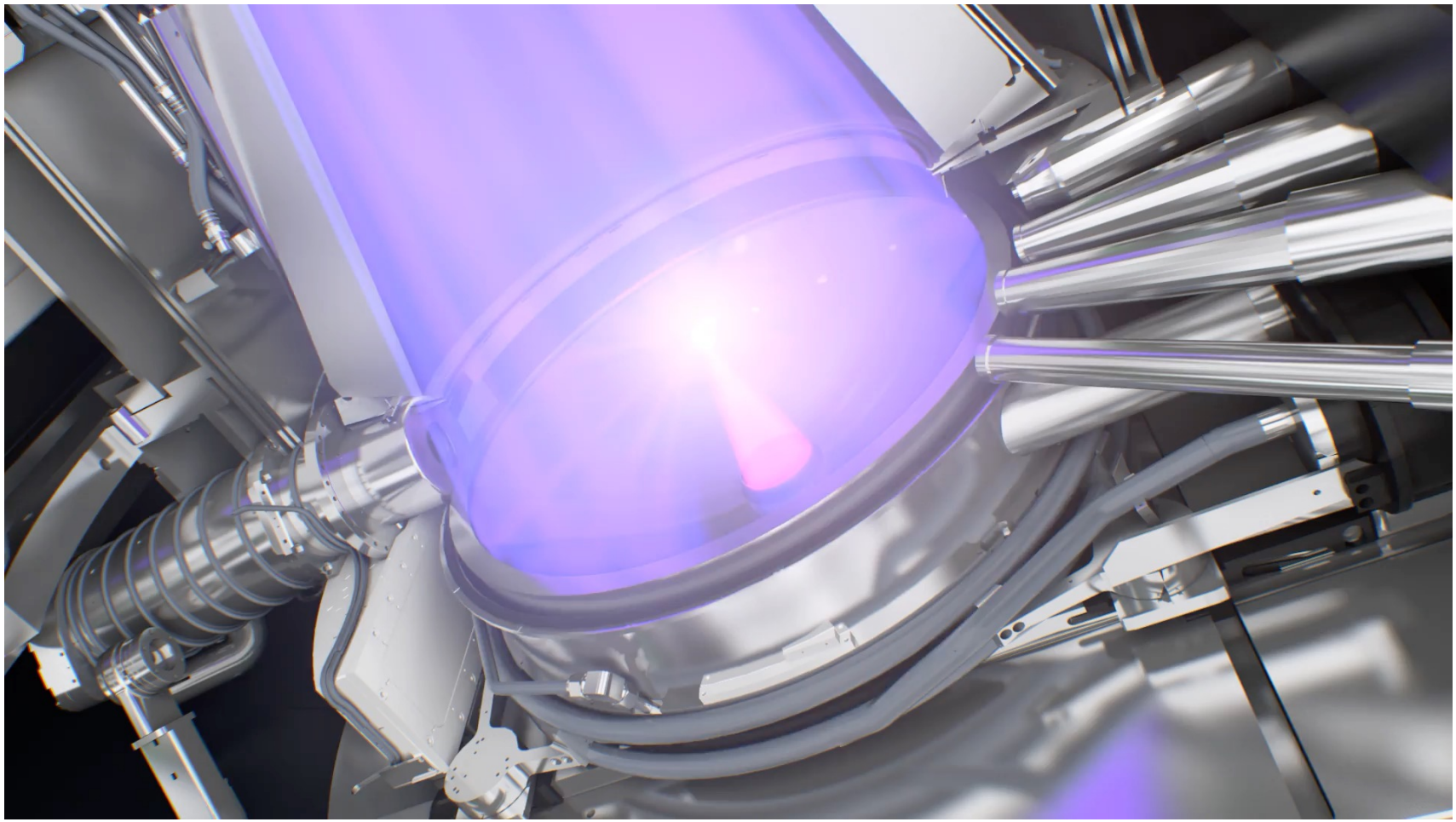
How to make EUV light? *tin plasma*



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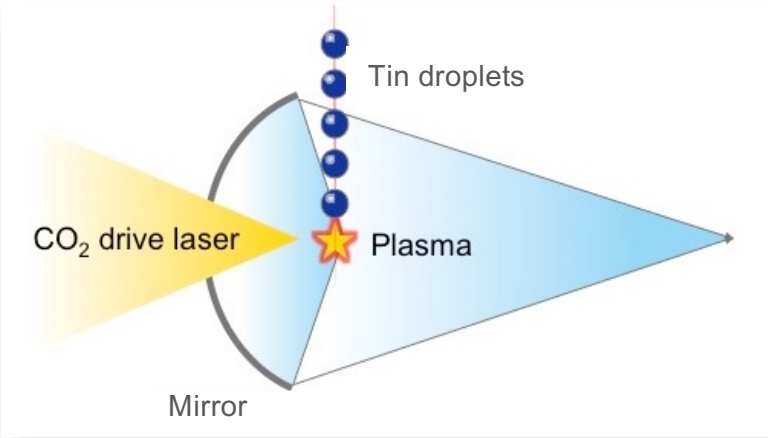
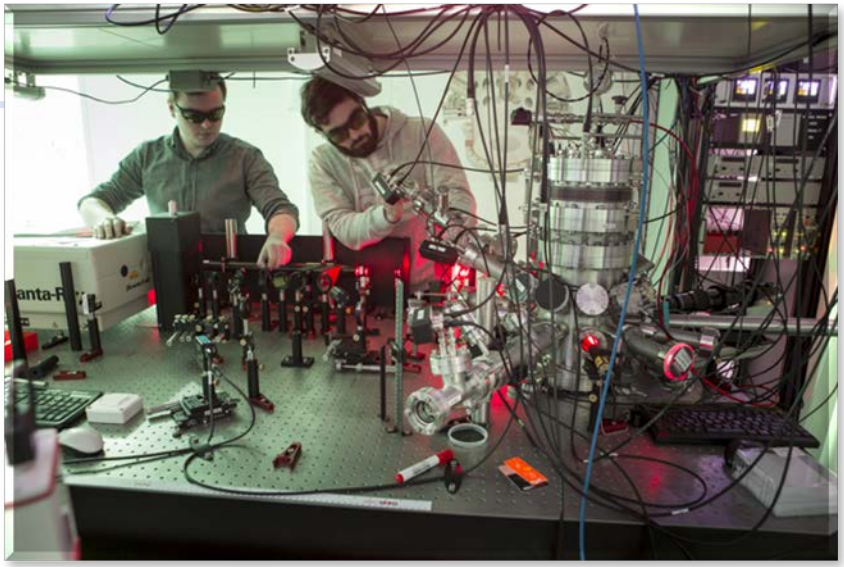
Source: ASML

How to make EUV light?

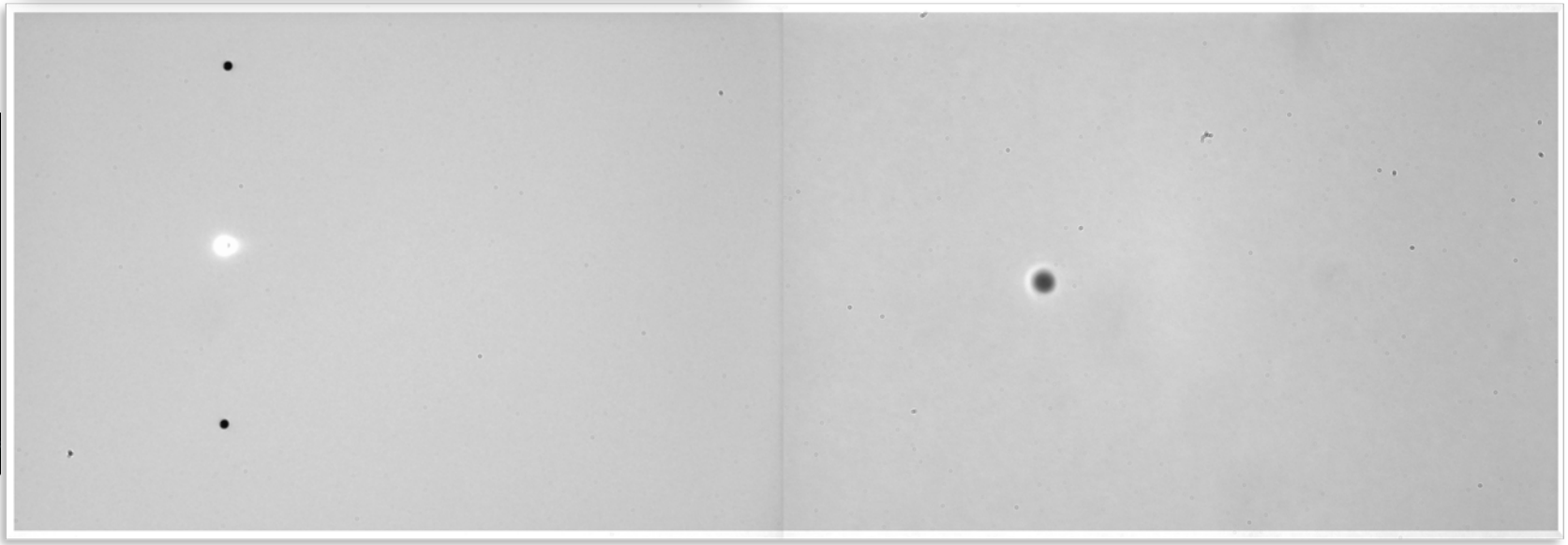
With tin douplets and intense laser light:

plasma hotter than the sun!





Movie of droplet after 'laser jab'



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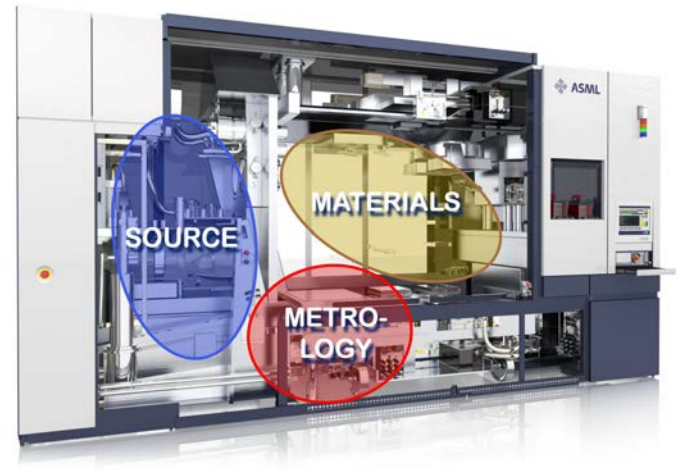

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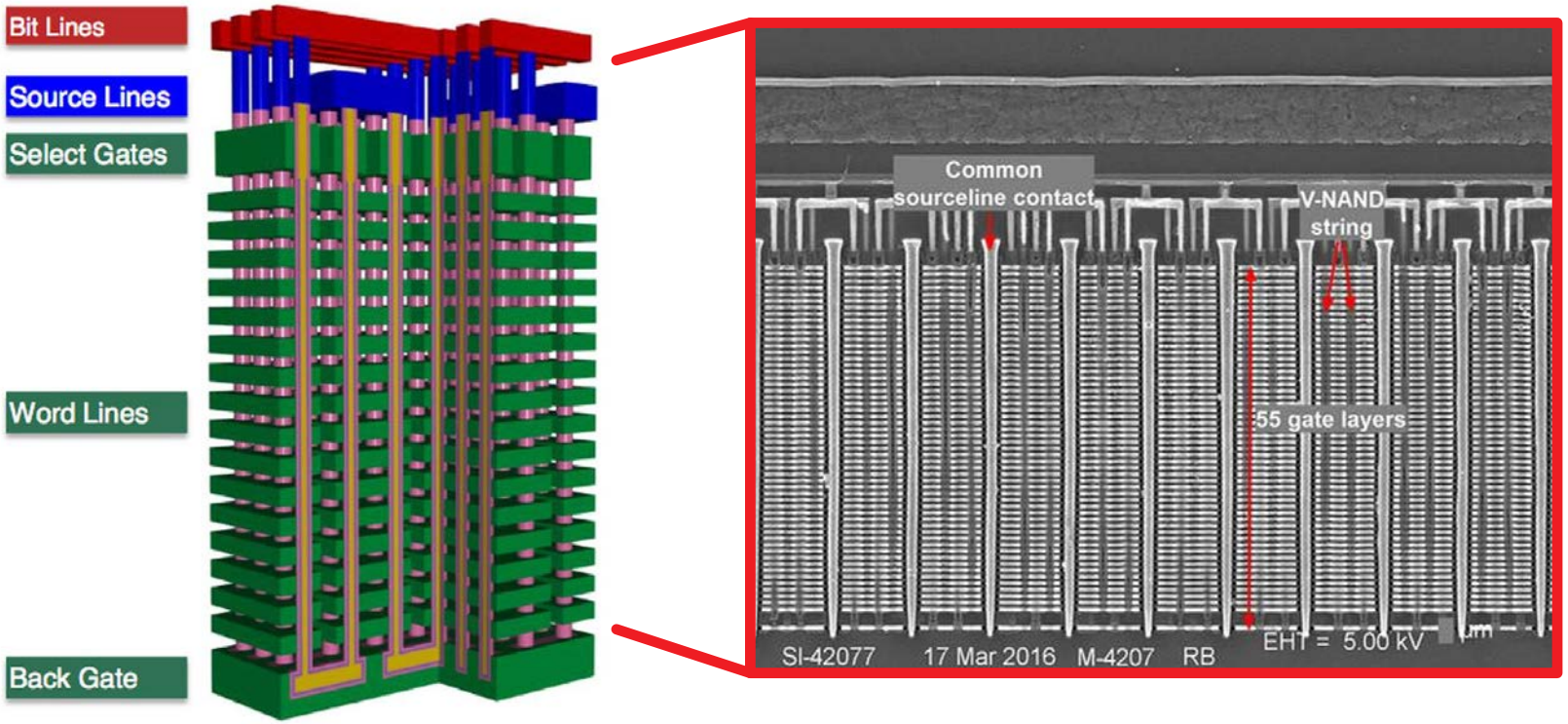
‘X-ray’ vision!?

Modern memory chips look like sky scrapers!



But how can you see through all that? With … sound!

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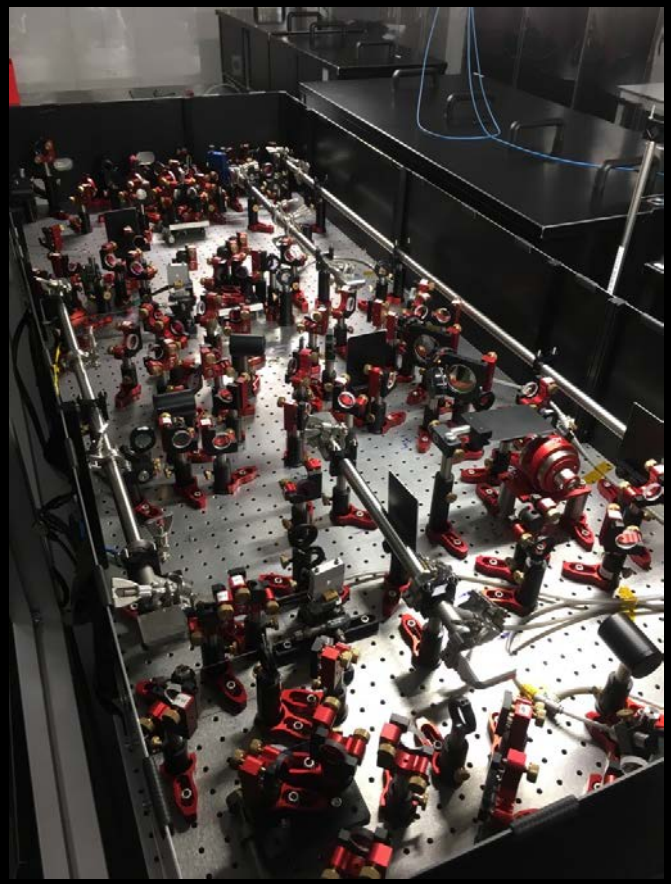
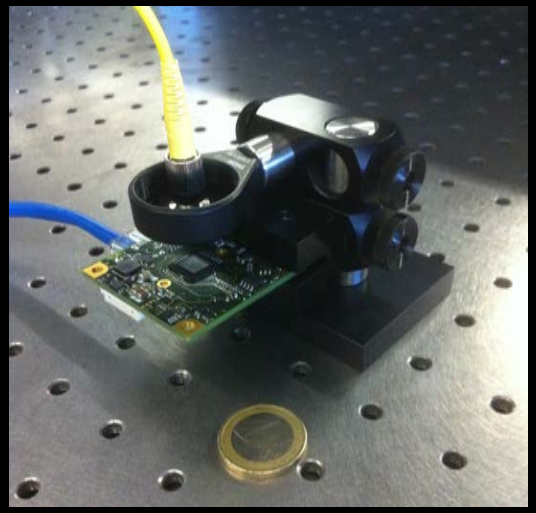
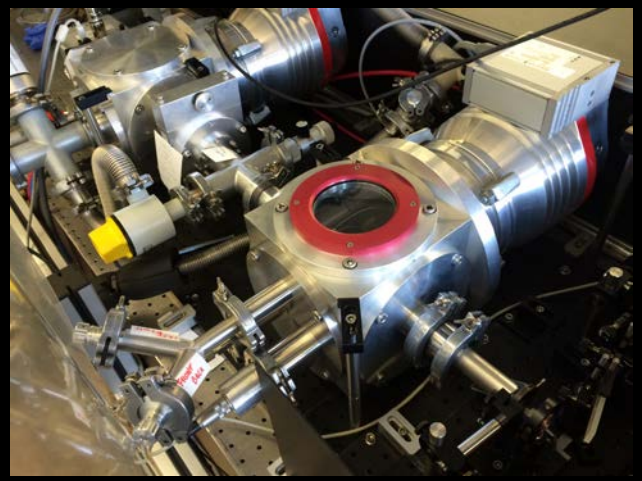
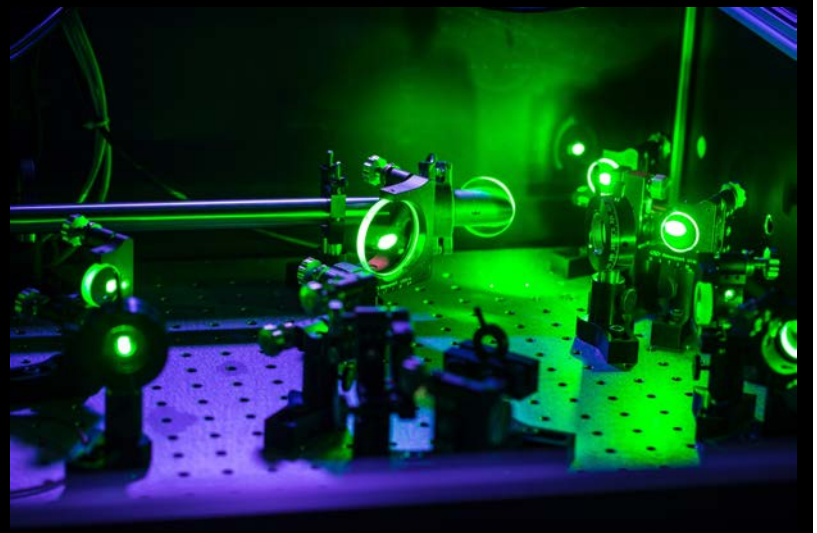
Source: Paul Planken and Stefan Witte

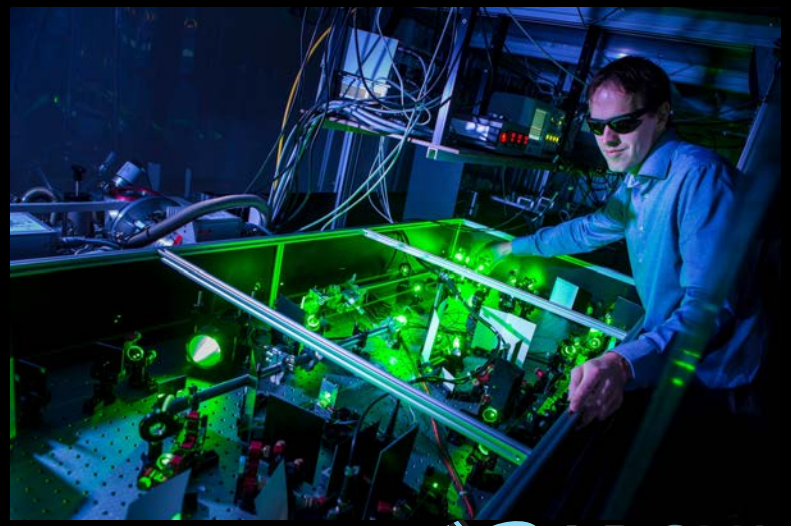
Metrology labs











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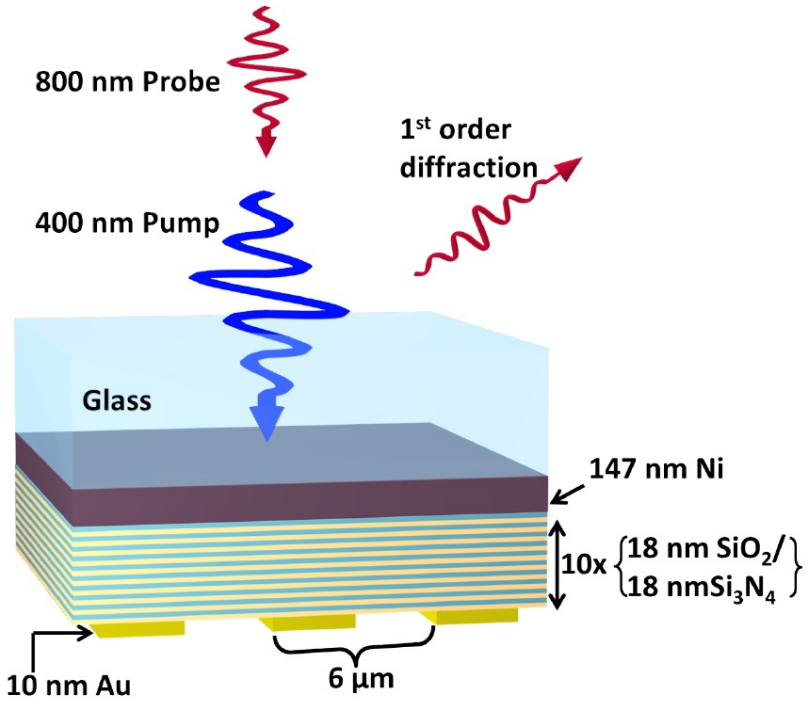
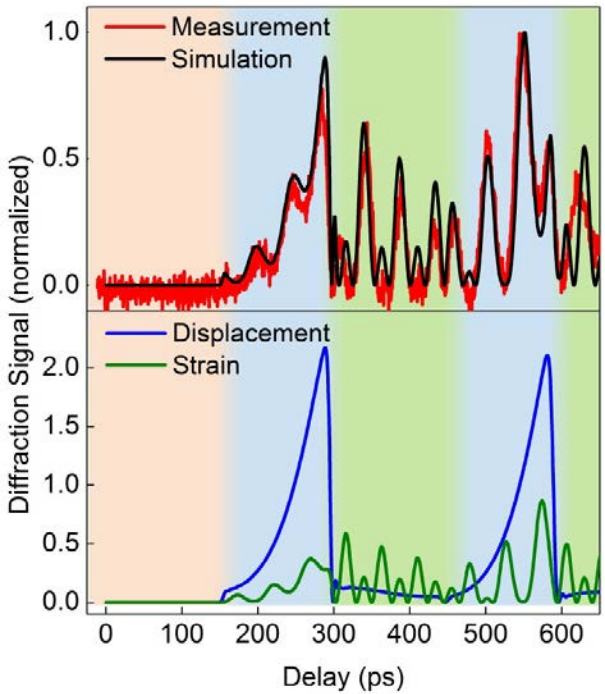
Making sound with light

Intense laser pulse as source of sound





Similar to how Shell searches for oil, we look below the surface with sound: just ‘a little’ smaller…

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Source: Paul Planken and Stefan Witte

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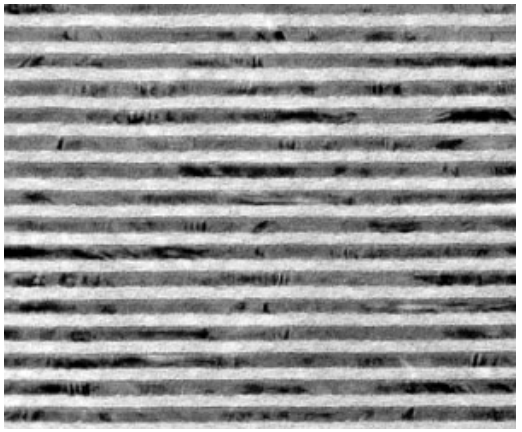
‘Laughing’-mirrors as lenses

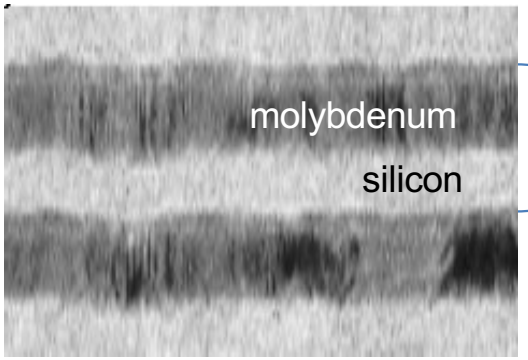
ZEISS CARL ZEISS SMT

Collector lense:
polished with atomic precision!!!

Mirror for **13.5 nm** light



Source: research group Prof. Fred Bijkerk
Universiteit Twente



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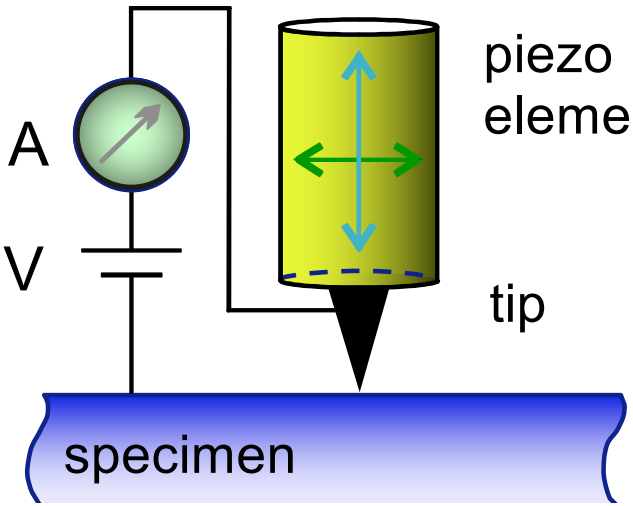
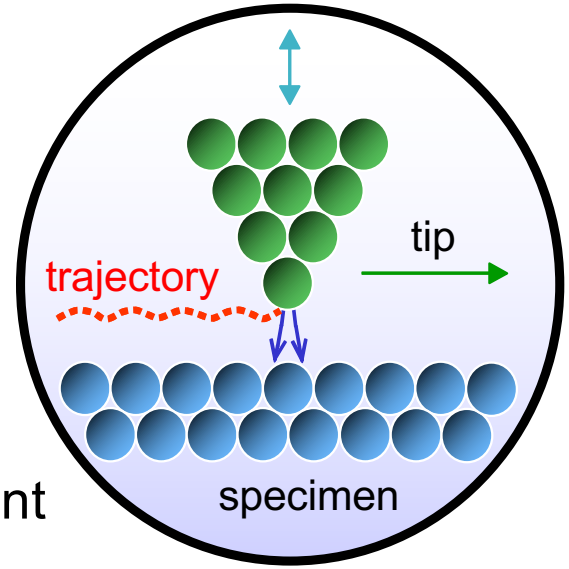
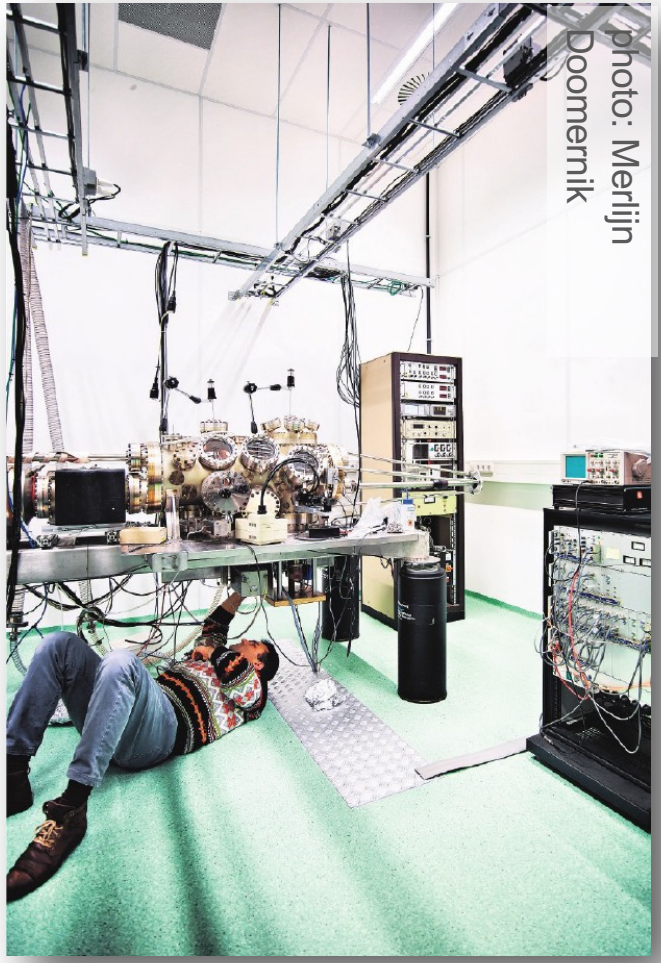
Scanning tunneling microscope

Marcel Rost and
Vincent Fokkema







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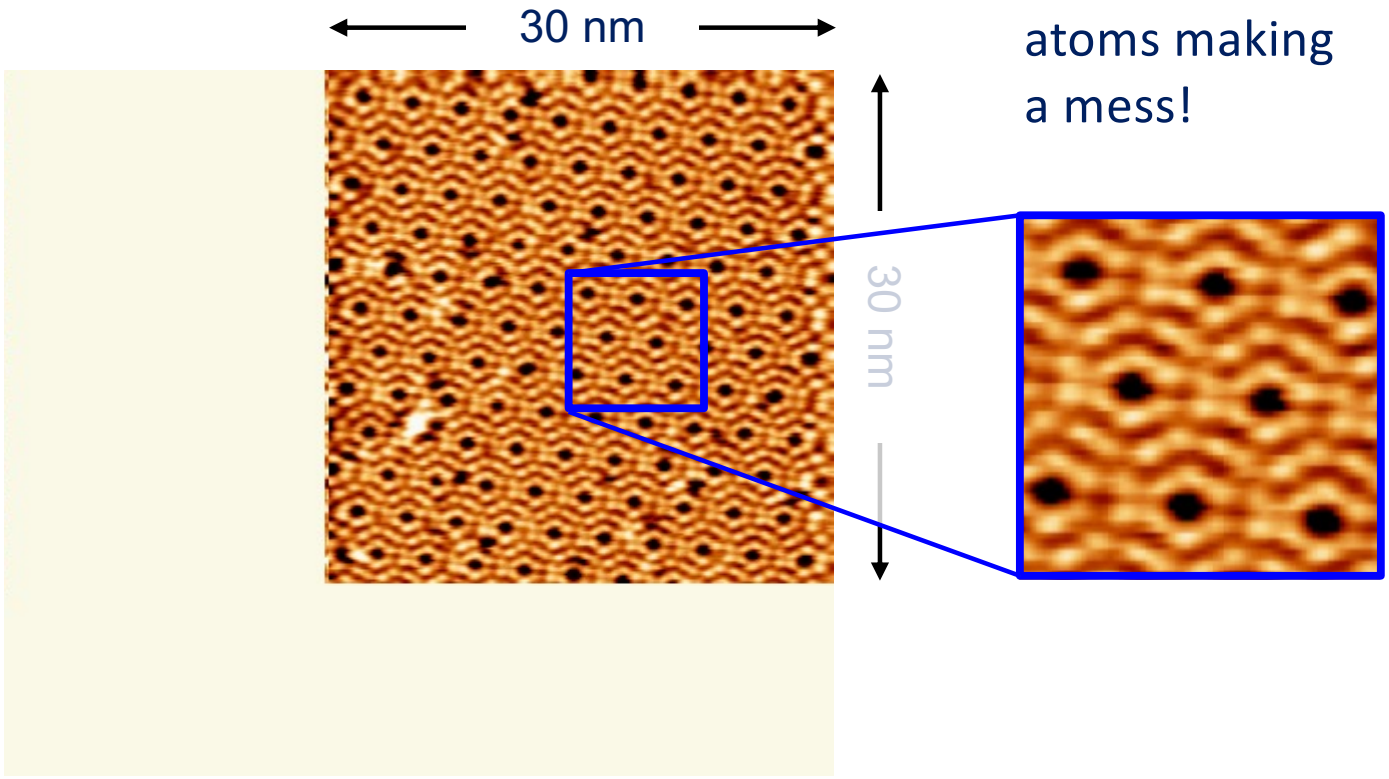
Atom-by-atom deposition

Molybdenum atoms on silicon

1.7 seconds per image



‘Fatal attraction’

atoms making a mess!

Marcel Rost
Vincent Fokkema
Universiteit Leiden

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Public-private connect: *INTEGRATION*



Dr. Maarten Voncken (ASML)
Dr. Marjan Fretz & Prof. Joost Frenken (ARCNL)

- Alignment of research program ARCNL with needs & interests ASML
- Organizational matters

ARCNL ⇔ ASML

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ARCNL's output & impact

- *Scientific*
  - Well over 100 publications: came up to speed in 2020
  - Organisation of conferences/symposia/workshops
  - Increasingly initiator of research networks & project/program proposals
- *Valorisation*
  - Well over 100 patent ideas from ARCNL to ASML
  - Of those over 40 incorporated in patents / patent applications
  - Much knowledge transfer through other channels: hard to quantify
- *Human capital*
  - 17 PhD's so far (several more planned): came up to speed in 2020
  - Good 'throughput' of BSc and MSc students, postdocs, technicians, …
  - 7 ARCNL-ers started at ASML, 1 ASML-er at ARCNL; various to other companies

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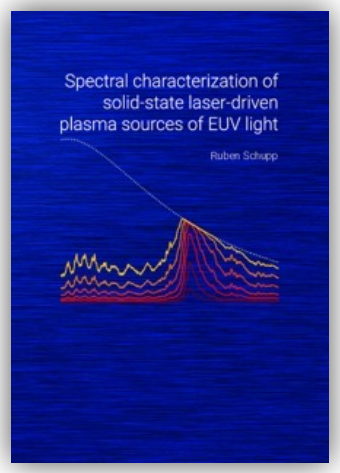
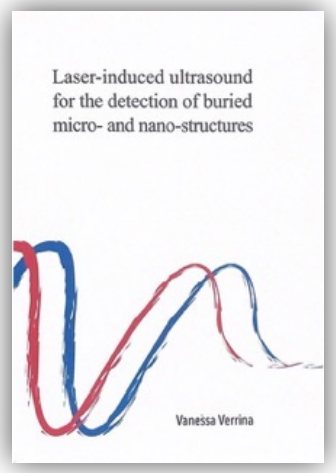
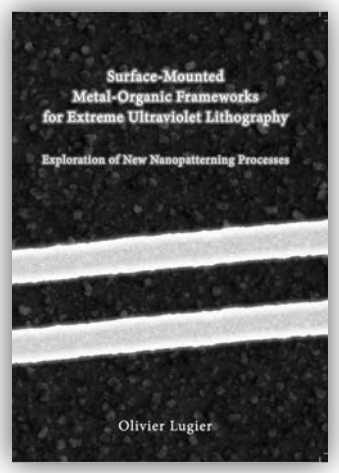
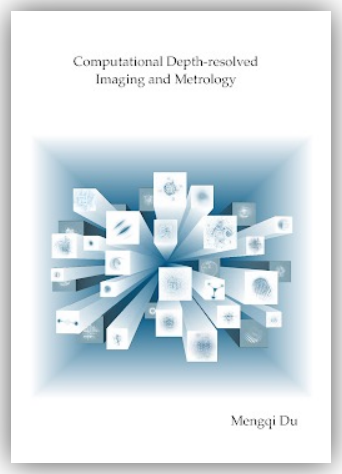
ARCNL's output

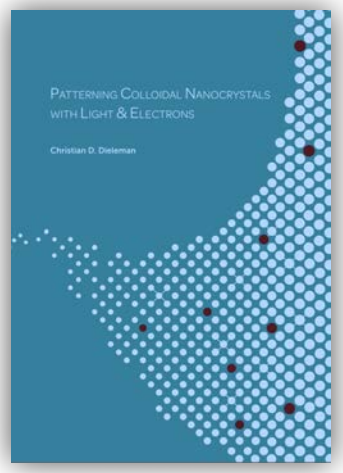
- *Publications (OA)*
  typically 40-60 research articles per year
- *PhD theses*
  number still rising (7 in 2021)
- *Patentable ideas*
  (mostly via ASML)
- *People*
  (often to ASML)

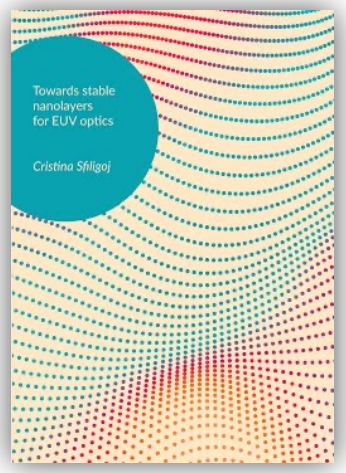


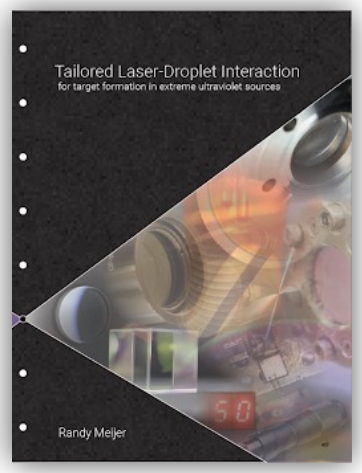












2021: 7
2020: 6
2019: 5
2017: 1

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Science with a Mission
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