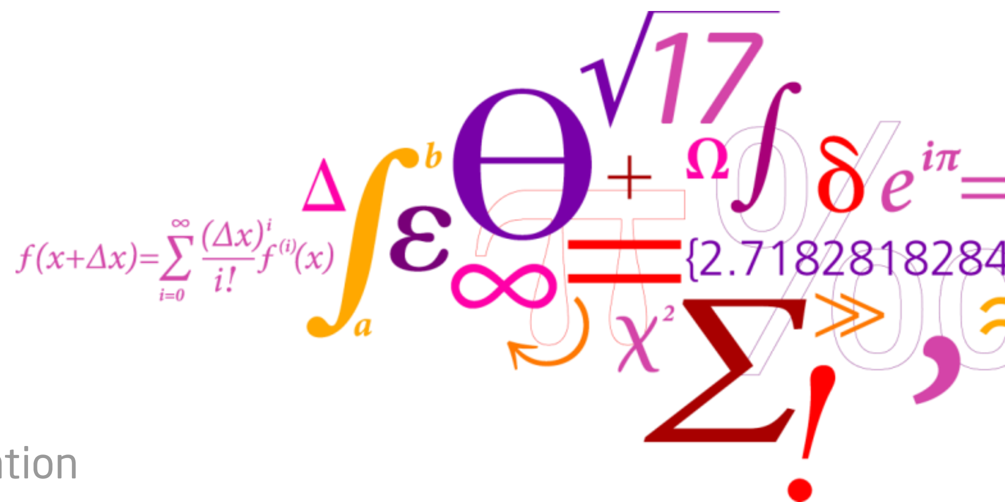
Laser Micromachining Tool 7.013

Chantal, Frederik, Helle, Jesper, Rune, Tine and Anders

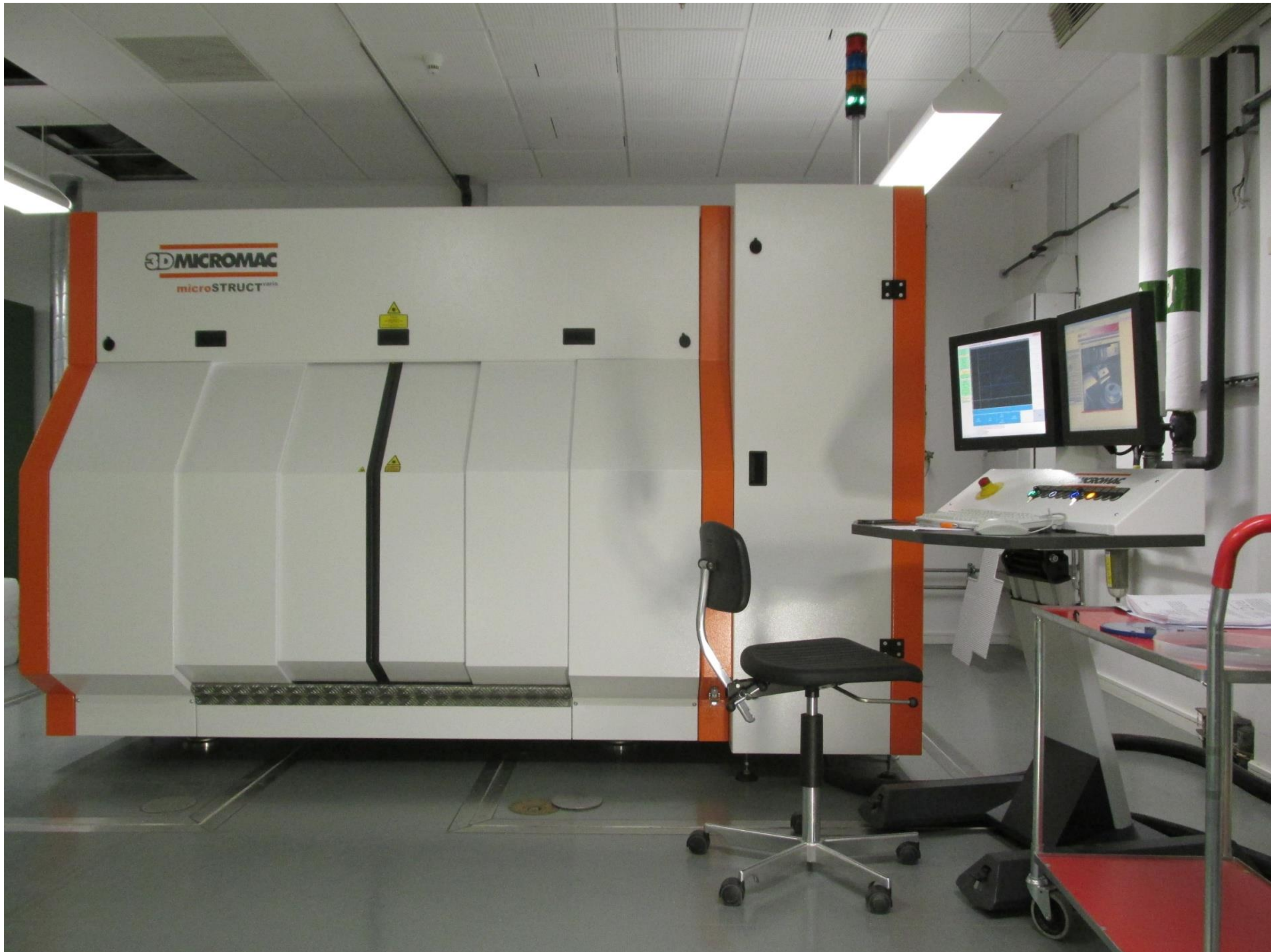


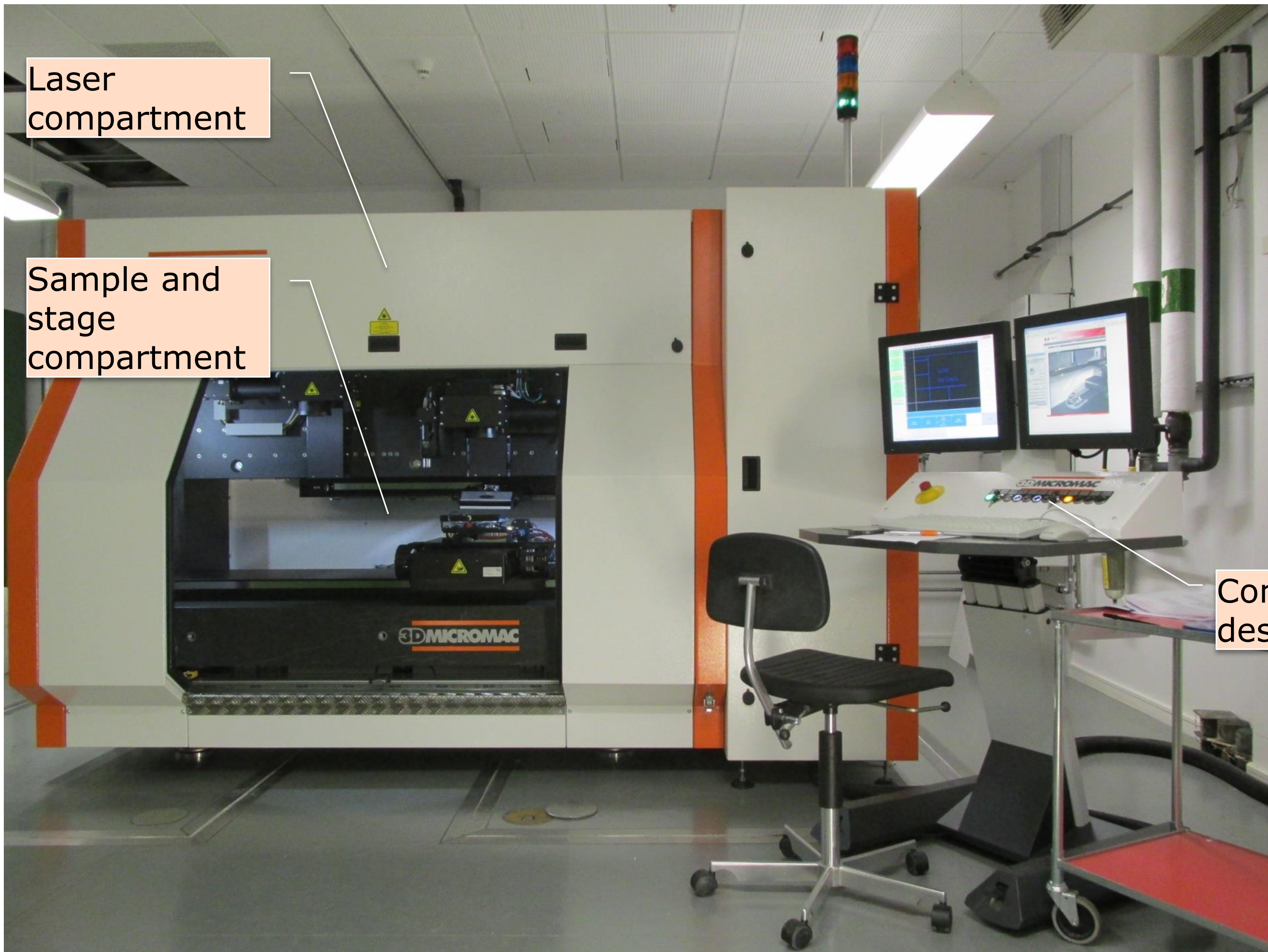
DTU Danchip
National Center for Micro- and Nanofabrication

Meet 6 tonnes of german engineering

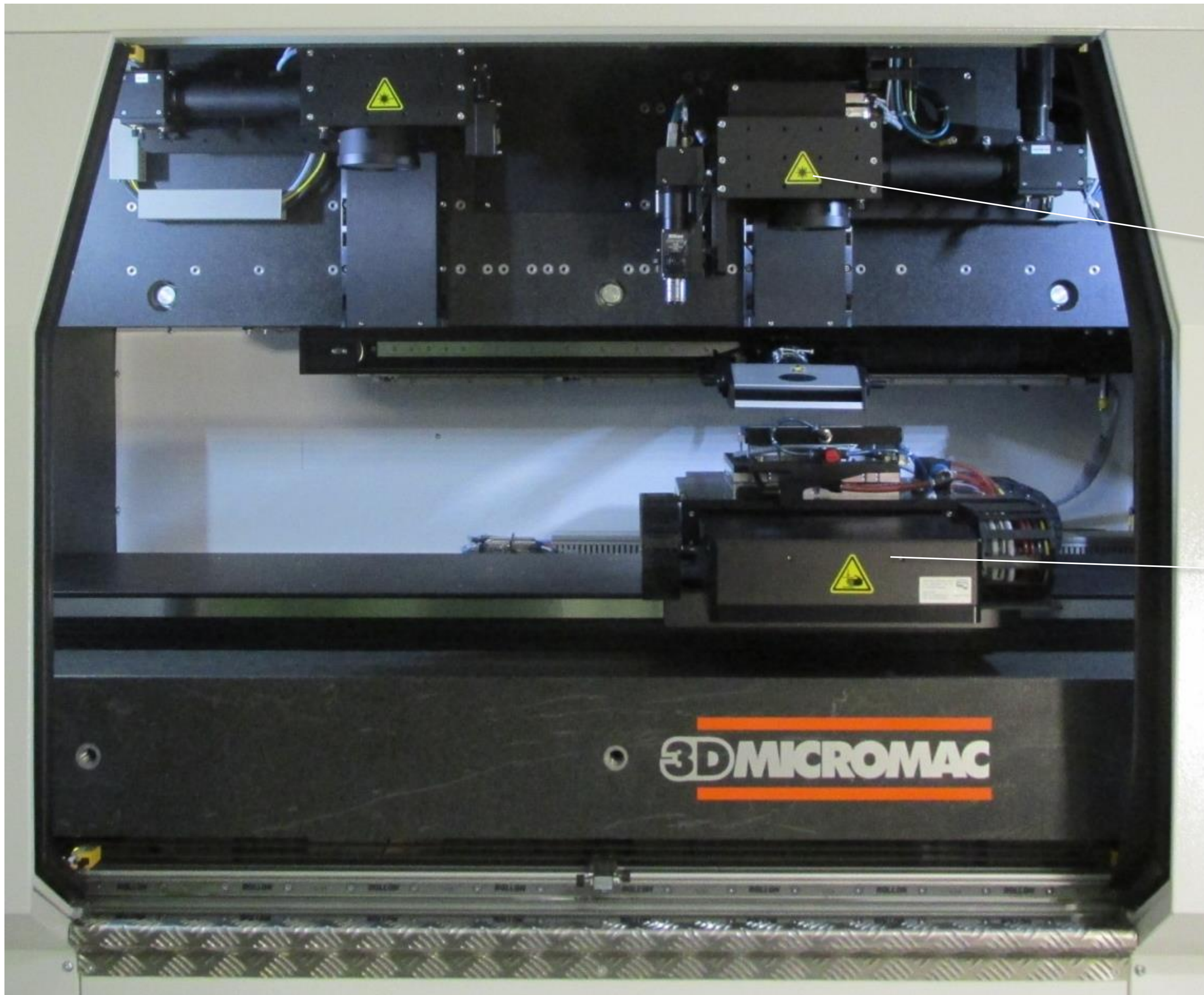
THE MACHINE

DTU



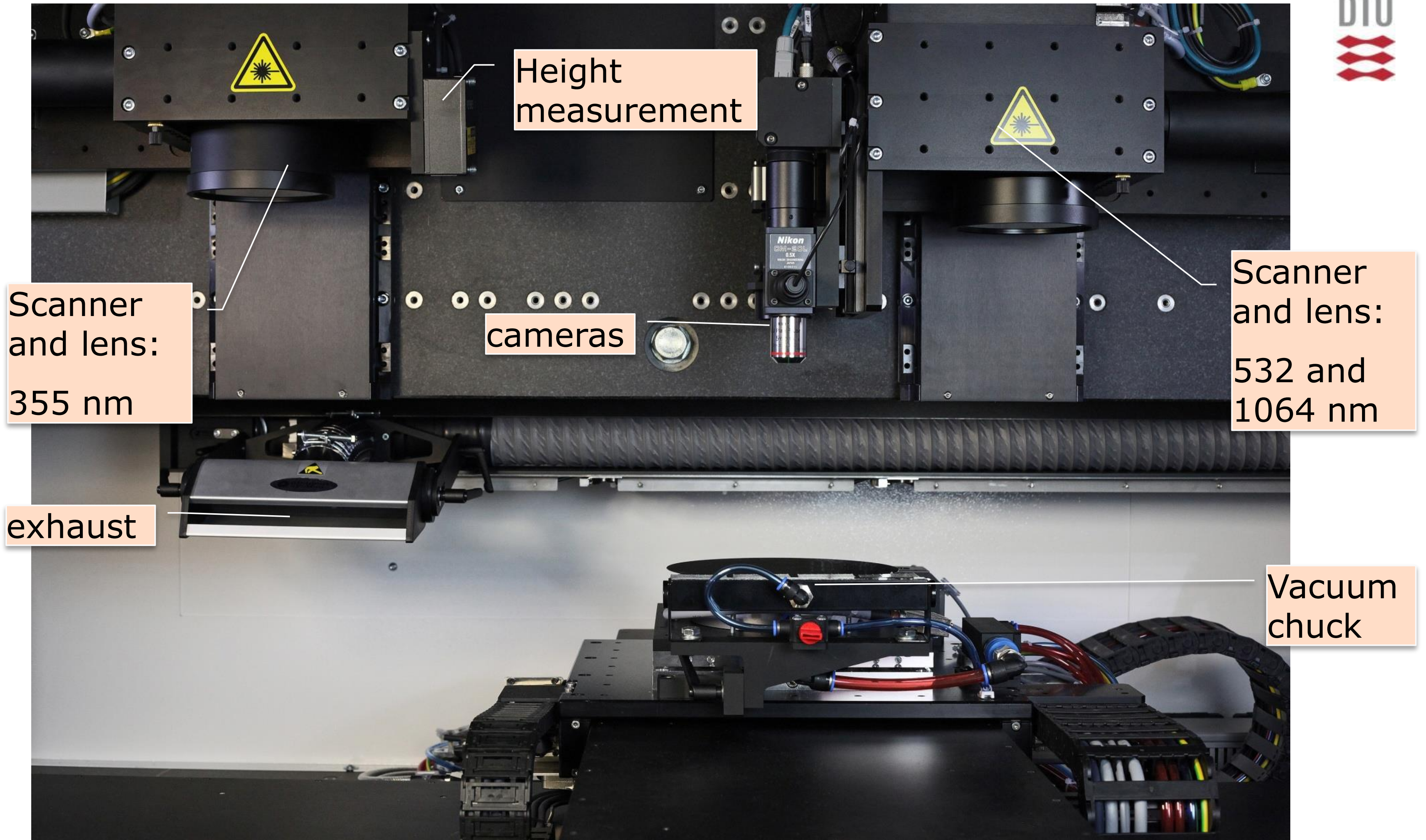


DTU

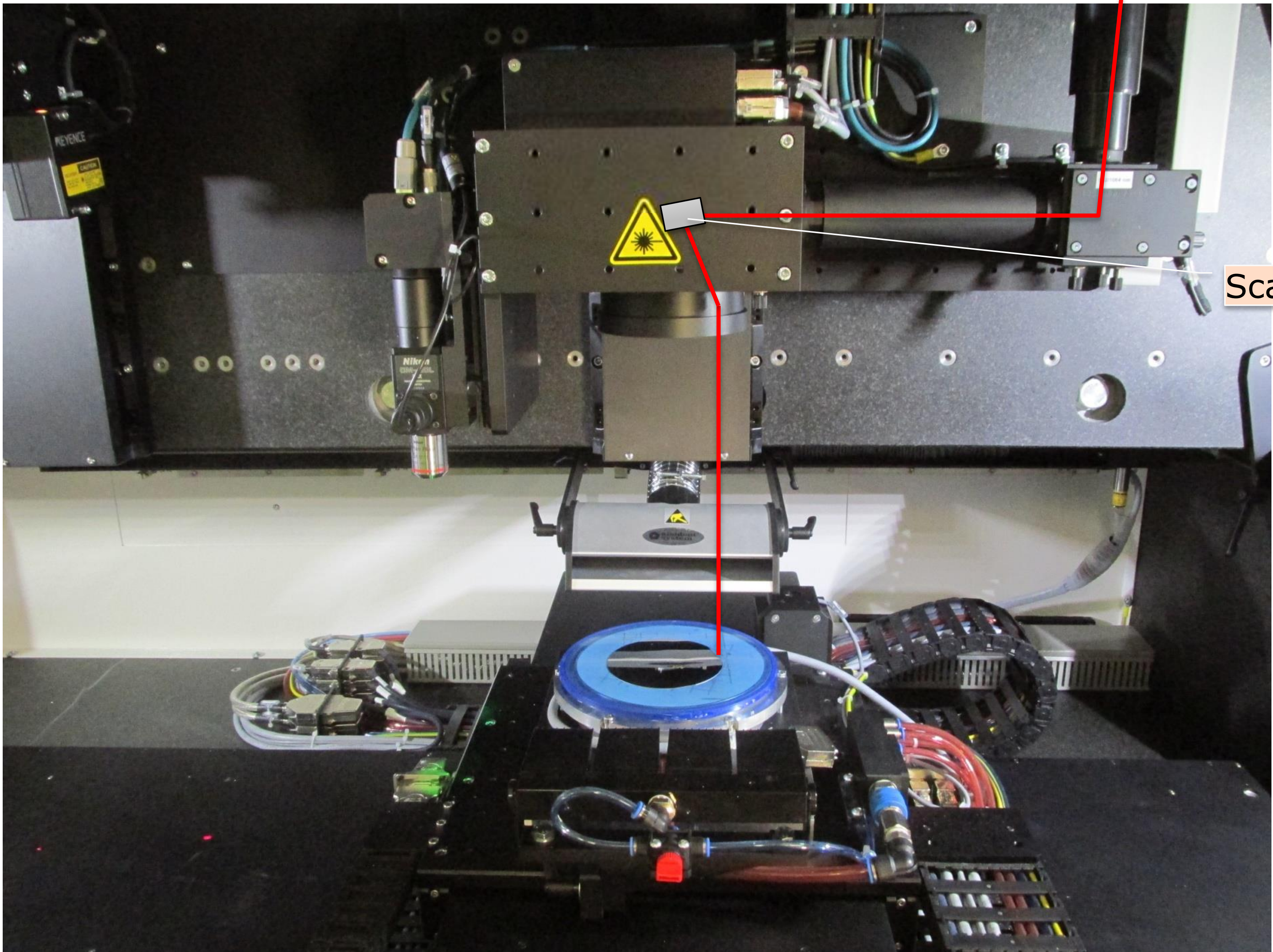


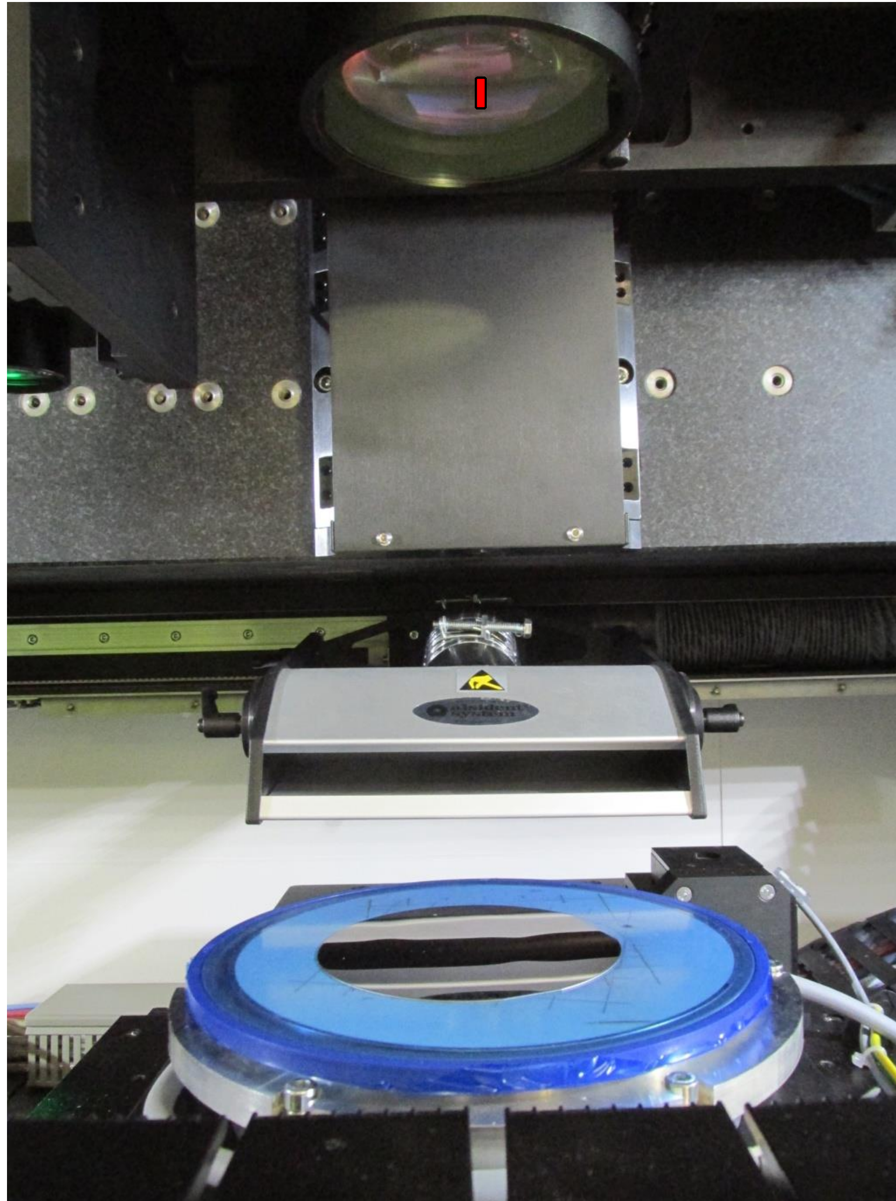
Scanner and lens

sample xy-stage


Height
measurement
Scanner
and lens:
355 nm
cameras
Scanner
and lens:
532 and
1064 nm
exhaust
Vacuum
chuck
Nikon

DTU

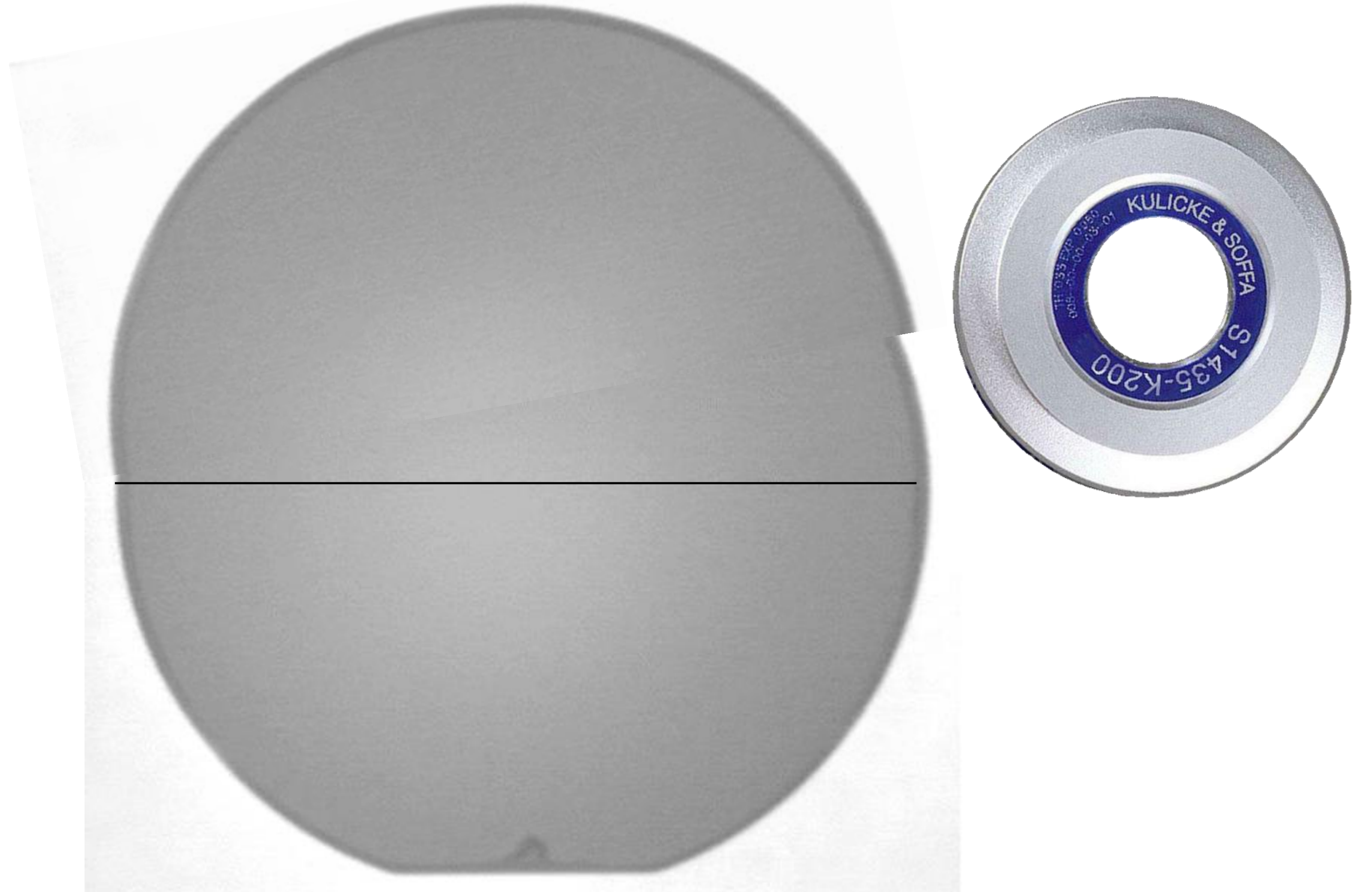

Scanner



Short pulse laser light and solid materials

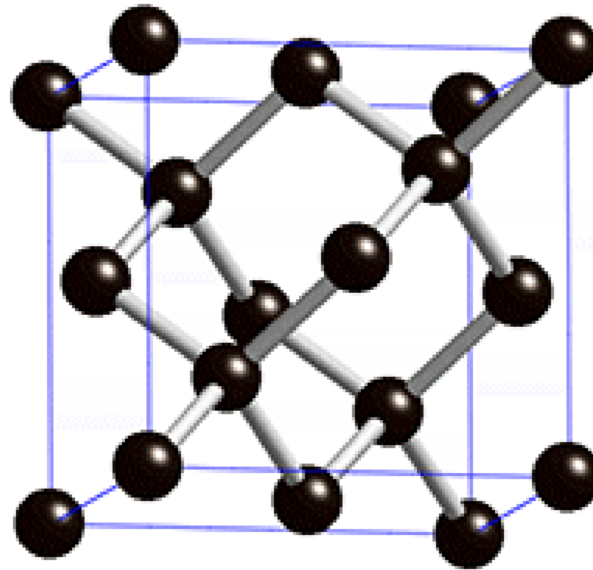
THE PHYSICS

For example: A Silicon Wafer

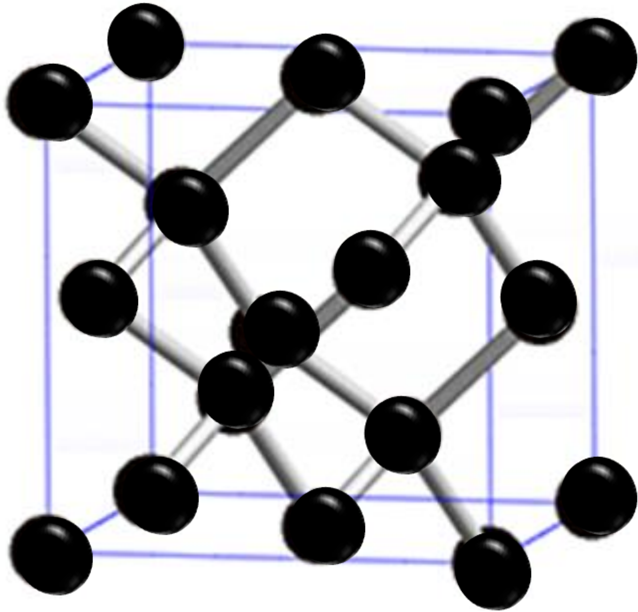


A Silicon Wafer: Pure Silicon

...and its Crystal Structur:



Physical specifications of pure Silicon:



Melting Point: 1700 K

Boiling Point: 3500 K

Heat of Evaporation: 30 kJ/cm^3

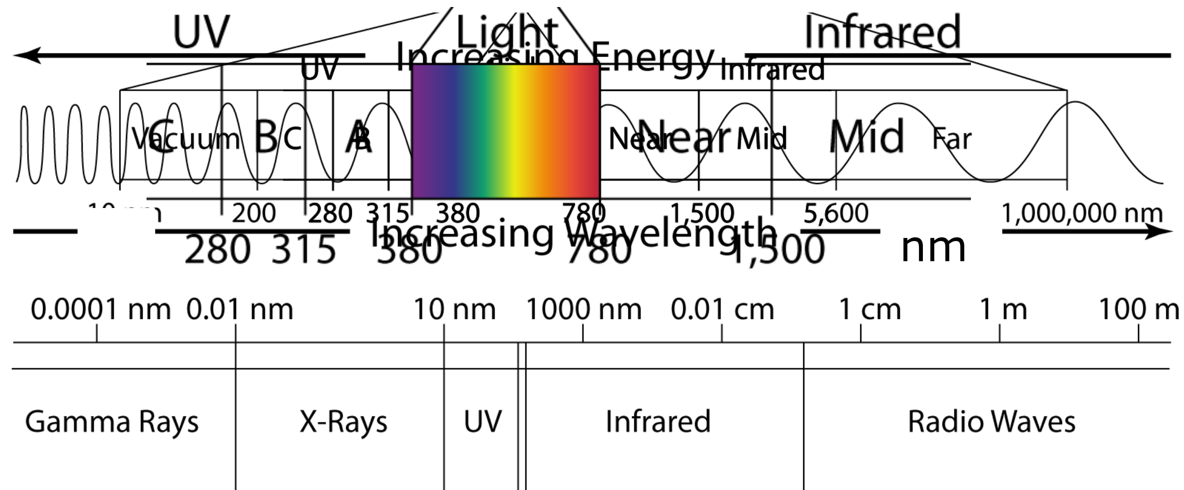
→Energy per chemical bond:

$3 \cdot 10^{-19}$ J = 2 eV

→Energy for evaporating a volume of 1 µm^3:

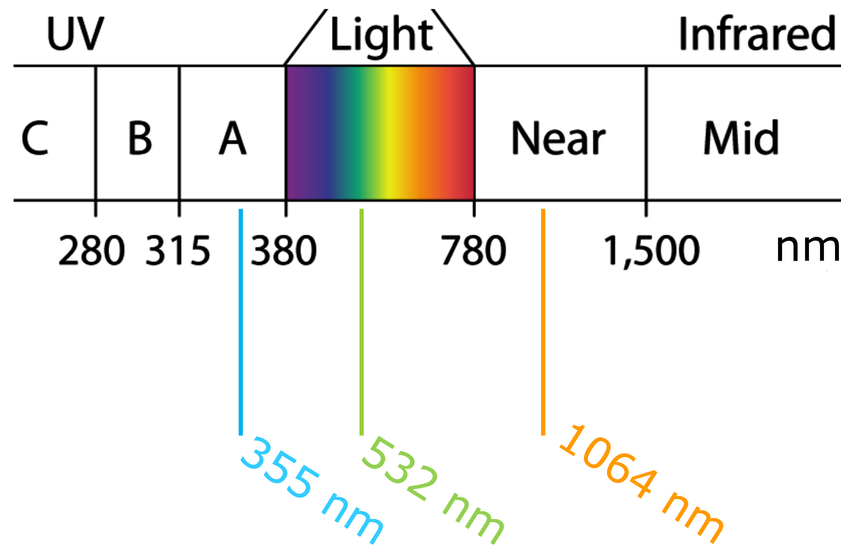
$3 \cdot 10^{-8}$ J = $1 \cdot 10^{11} \cdot 2$ eV

Laserlight



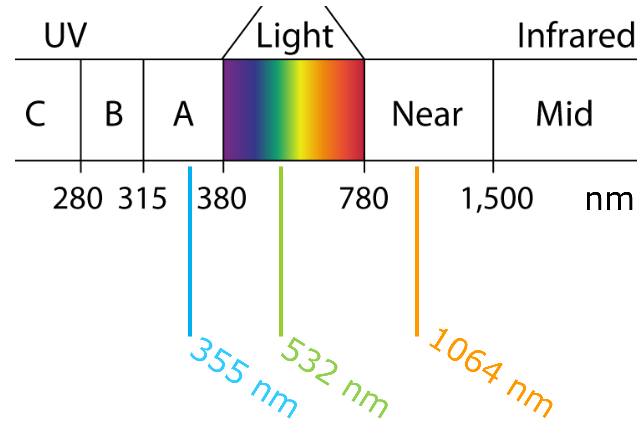
http://www.windowimage.sg

Laserlight

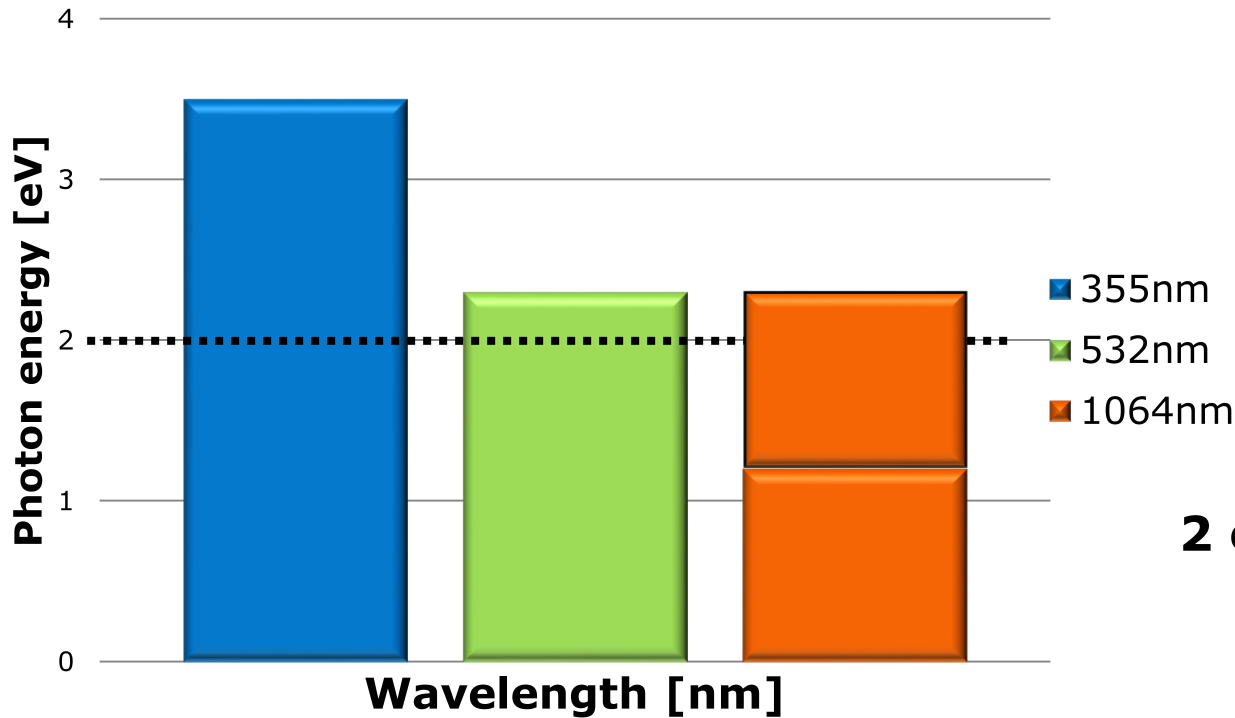


http://www.windowimage.sg

Laserlight



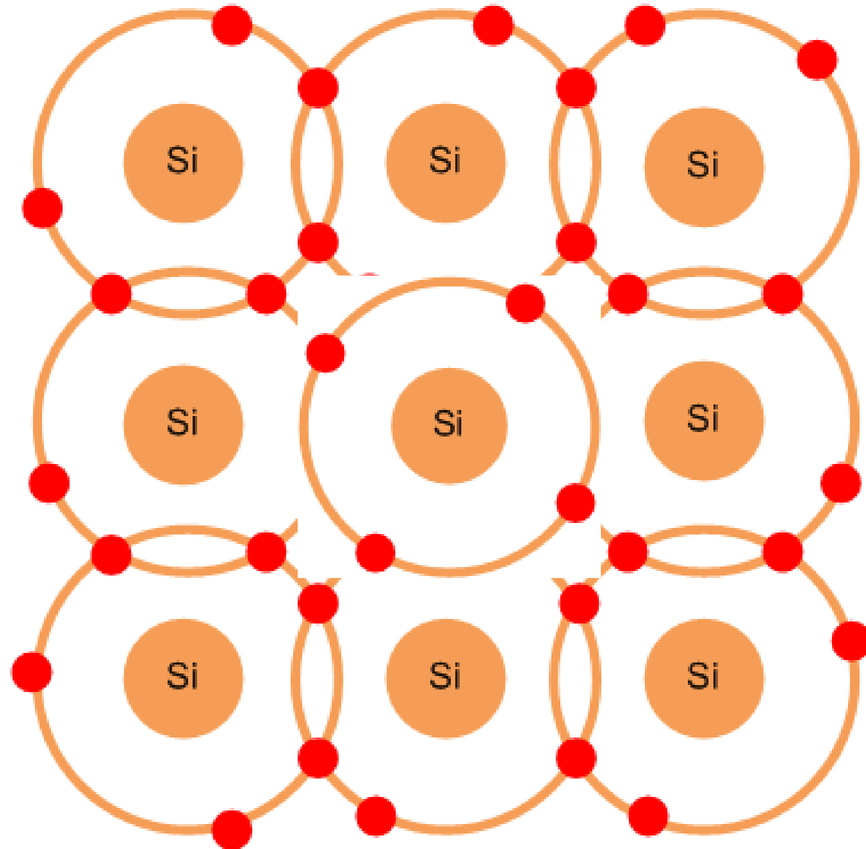
Relation : $E = (hc)/\lambda$ [eV]



2 eV ≙ Si-Si Bondenergy

http://www.windowimage.sg

Releasing a Silicon Atom



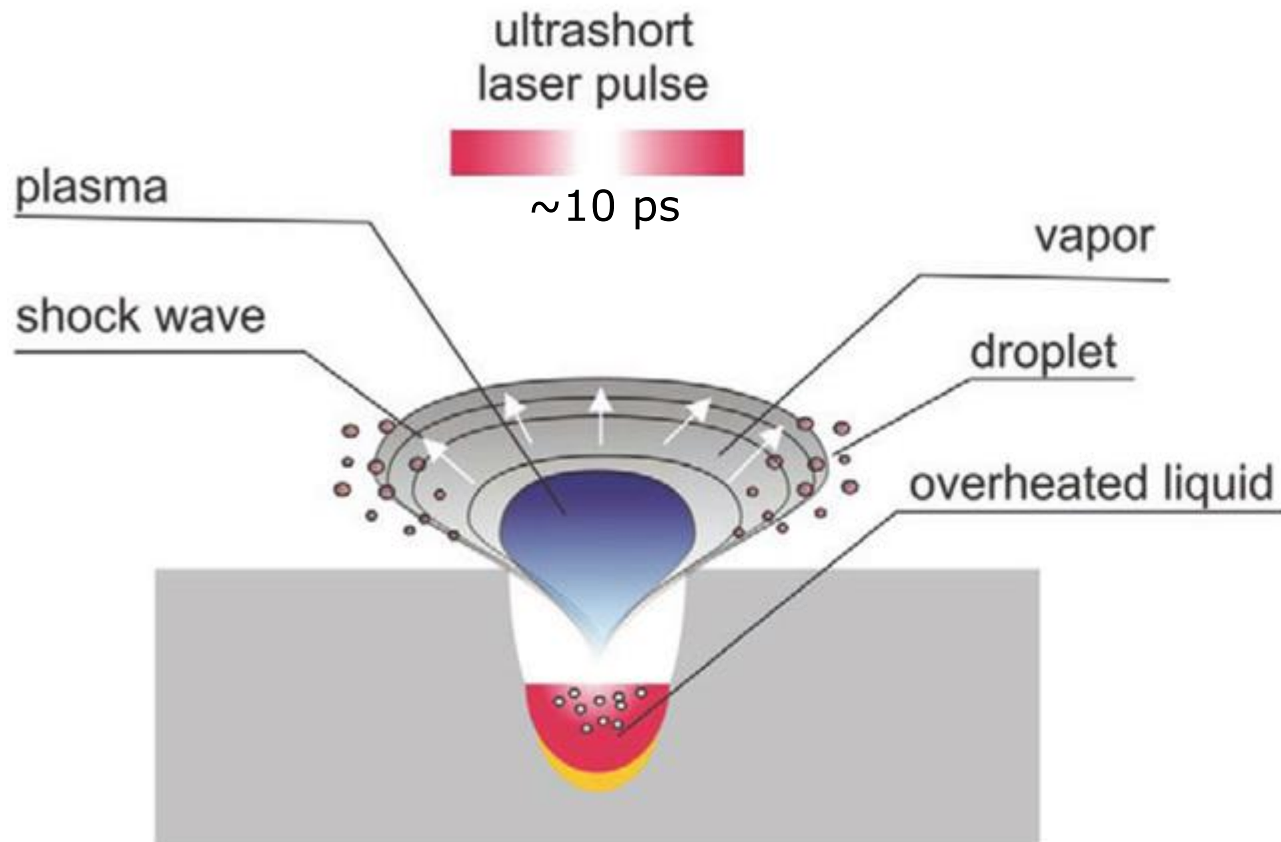
4 green photons

or

8 red photons

http://www.windowimage.sg

How does Laser machining work in principle?

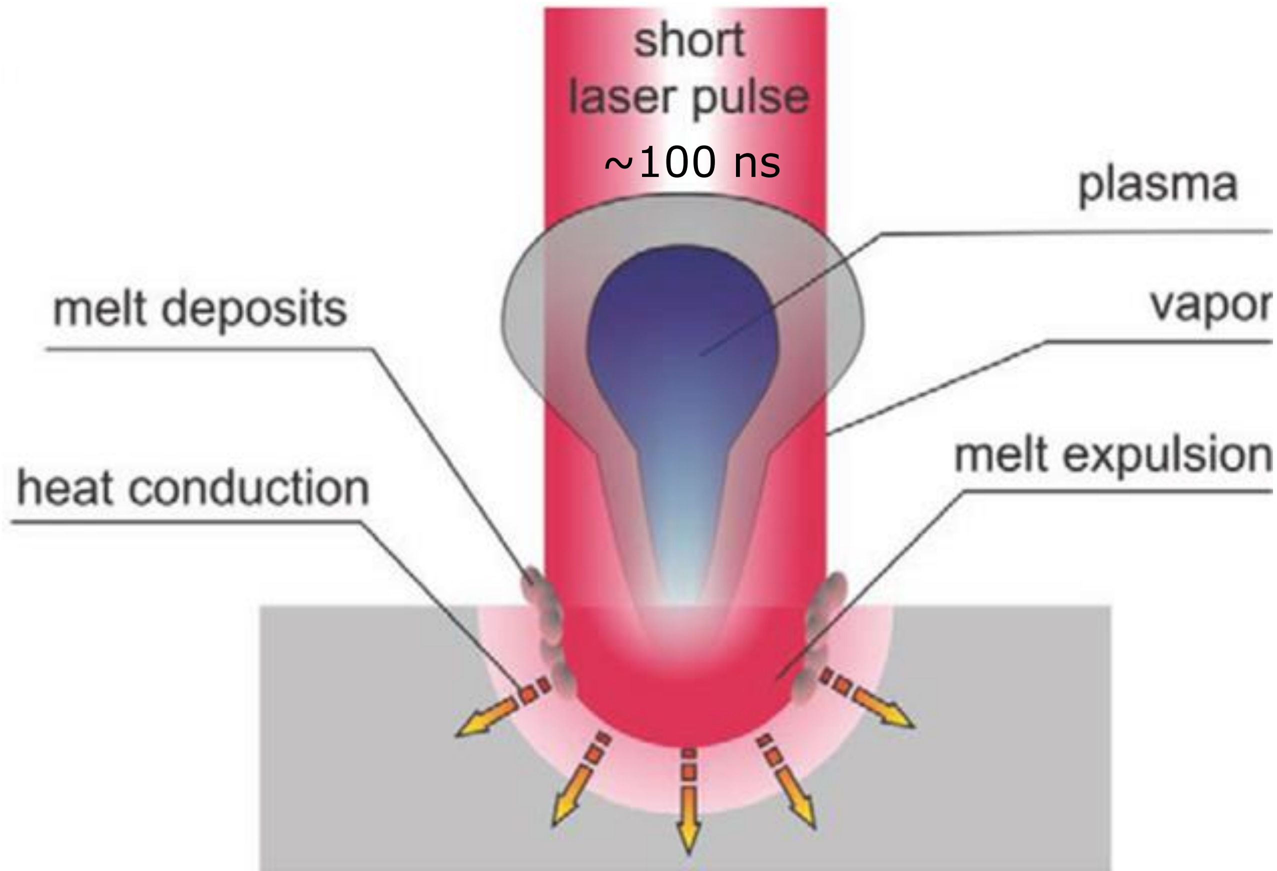


Pules by Pulse – layer by layer – material is removed.

No (less) debris → high precision process.

Leitz et al., Physics Procedia 12 (2011)

How does Laser machining work in principle?



Pules by Pulse – layer by layer – material is removed.

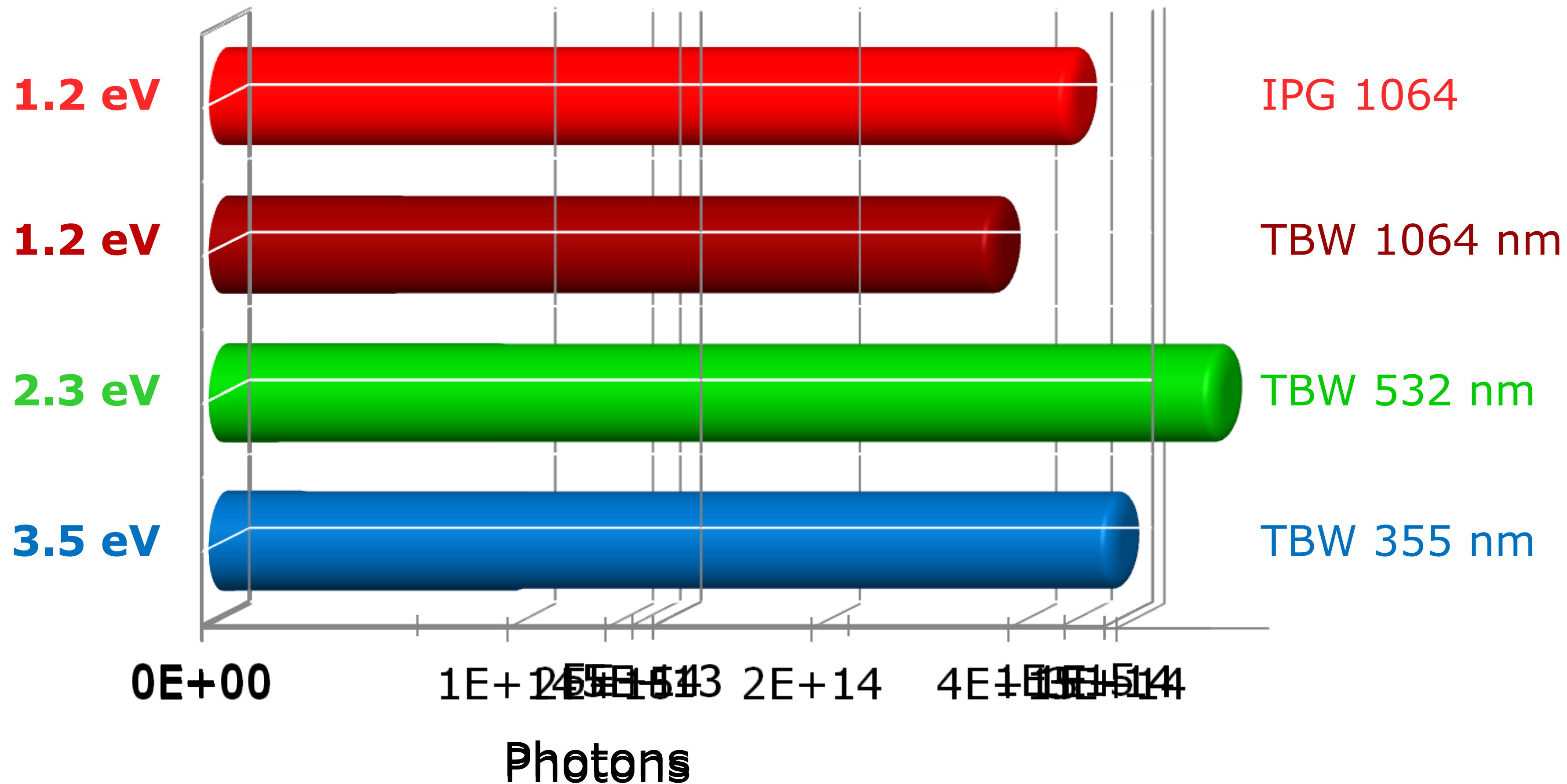
The cost of processing speed is quality.

Leitz et al., Physics Procedia 12 (2011)

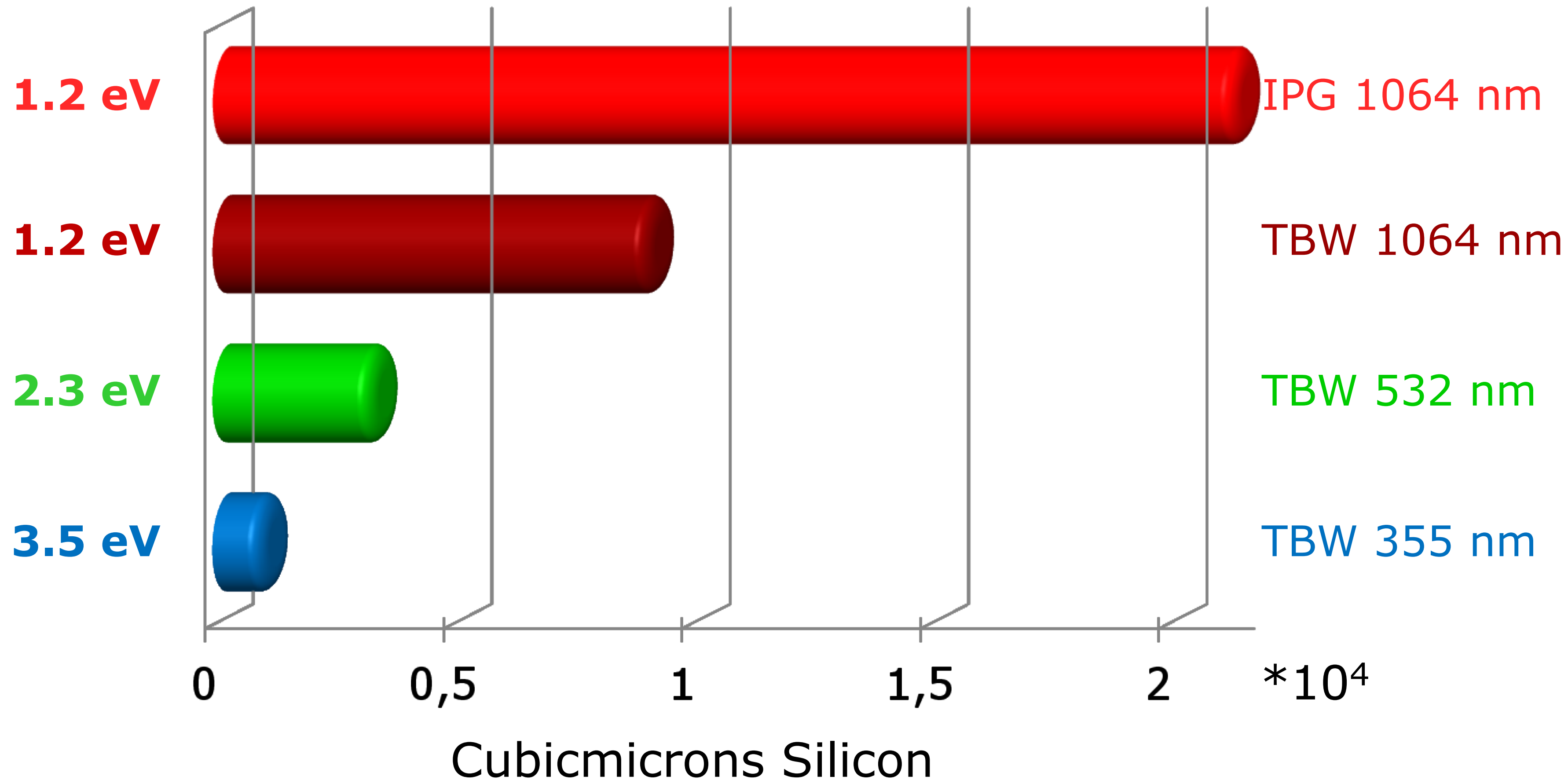
The Machine's Laser System

Parameter	Unit	Min	Typ	Max
Pulse duration	ps	10.4	?	105 000

The number of photons per pulse



Evaporated volume per pulse



10 ps laser pulse with 1 MHz repetition rate

Open your eyes for 1 second

Keep them closed for a day

www.printed-editions.com

10 ps laser pulse

http://www.hainenko.com

How to envision a flux of 5.4 TW/cm²?

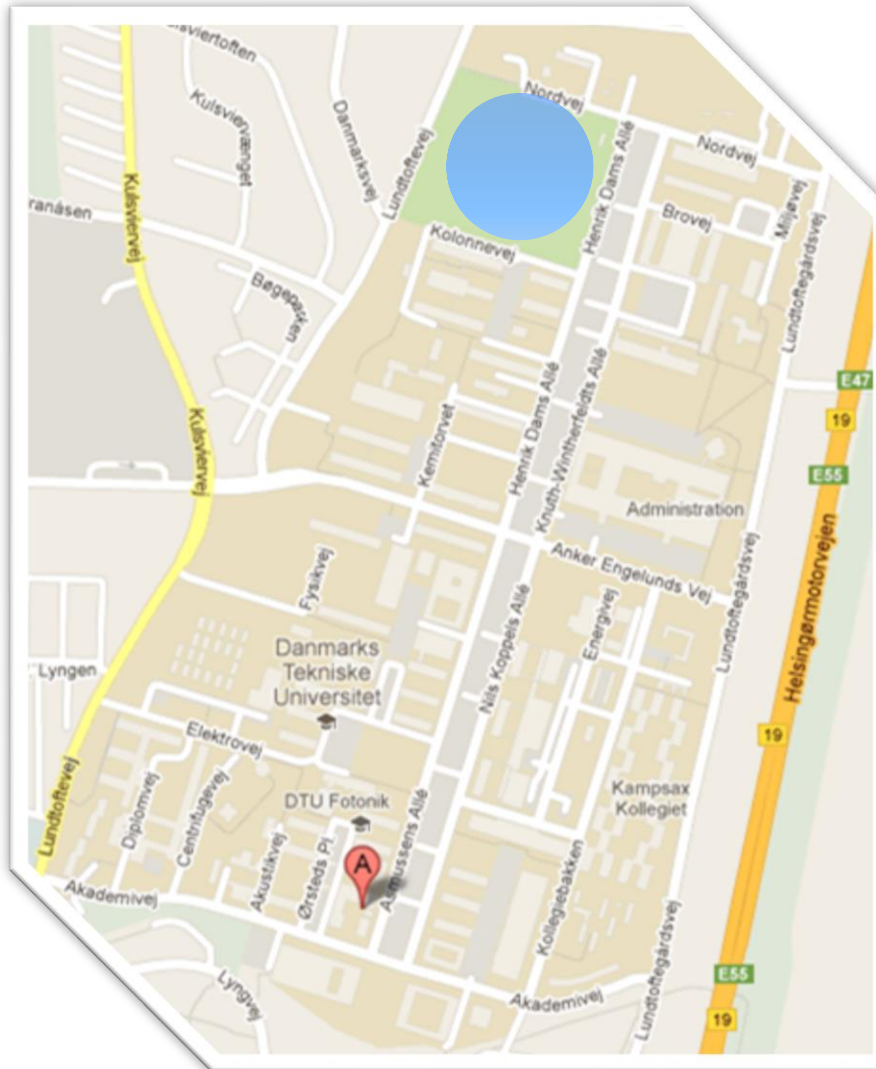
Lens = 20 cm

Spot = 20 µm

Spot = 2 mm

http://ang-sambal.blogspot.dk/

How to envision an irradiance of 5.4 TW/cm^2?



A lens of 200 meter in diameter would be required!

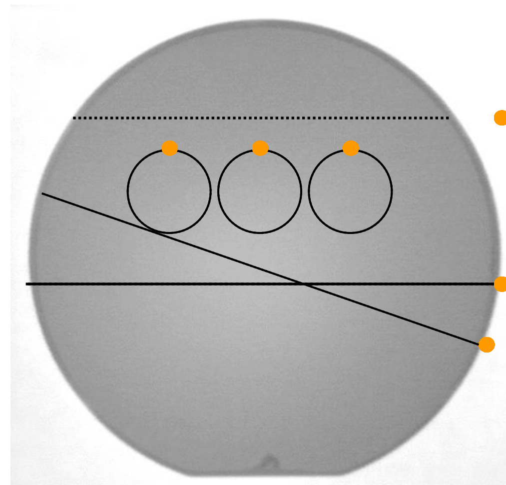
http://maps.google.com/

How does Laser machining work in practice?

Dicing a Wafer

Laser–Material Interaction: 1 minute

Iterations: 1000 times



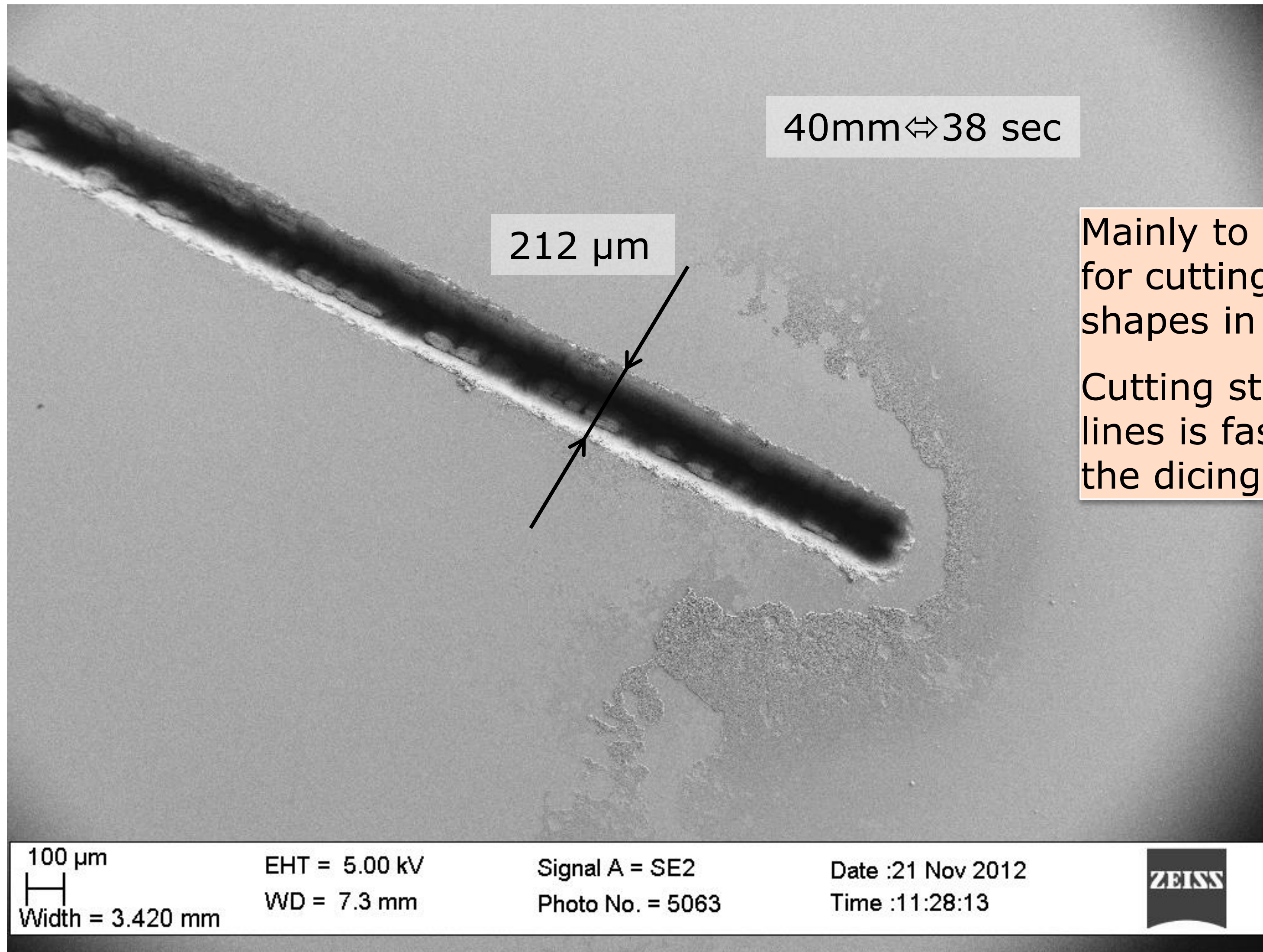
Scanspeed: 2000 mm/s

10^7 pulses in total

Where can it used?

APPLICATIONS

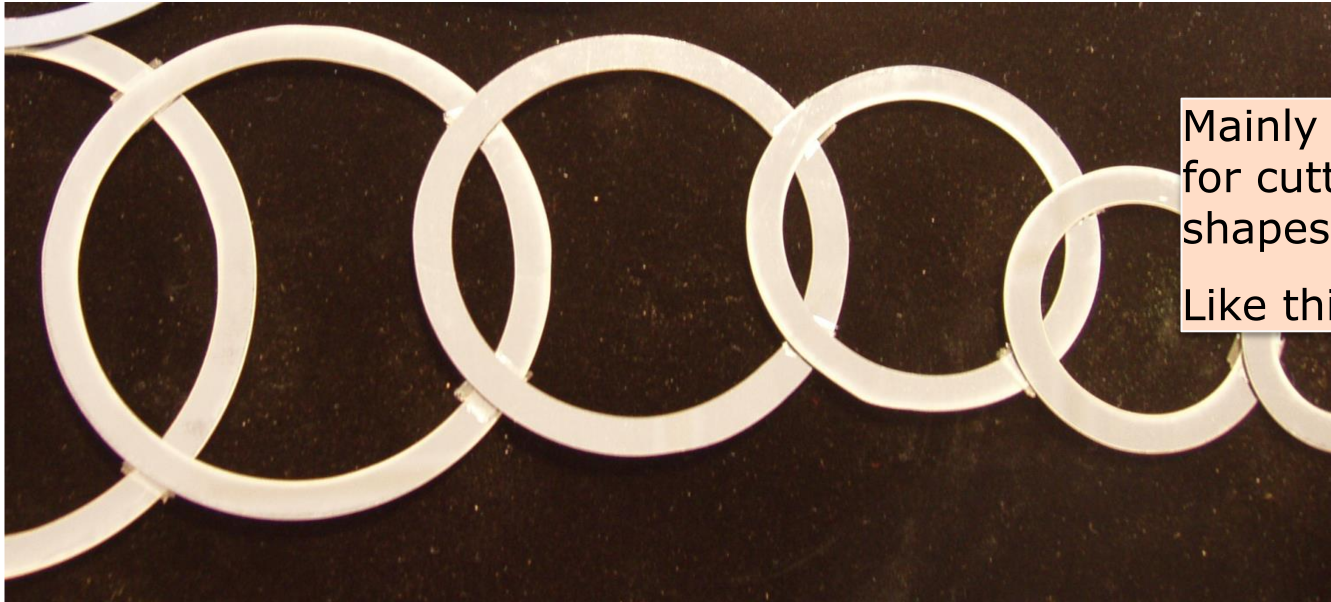
Dicing Silicon



Mainly to be used for cutting odd shapes in silicon.

Cutting straight lines is fast using the dicing saw

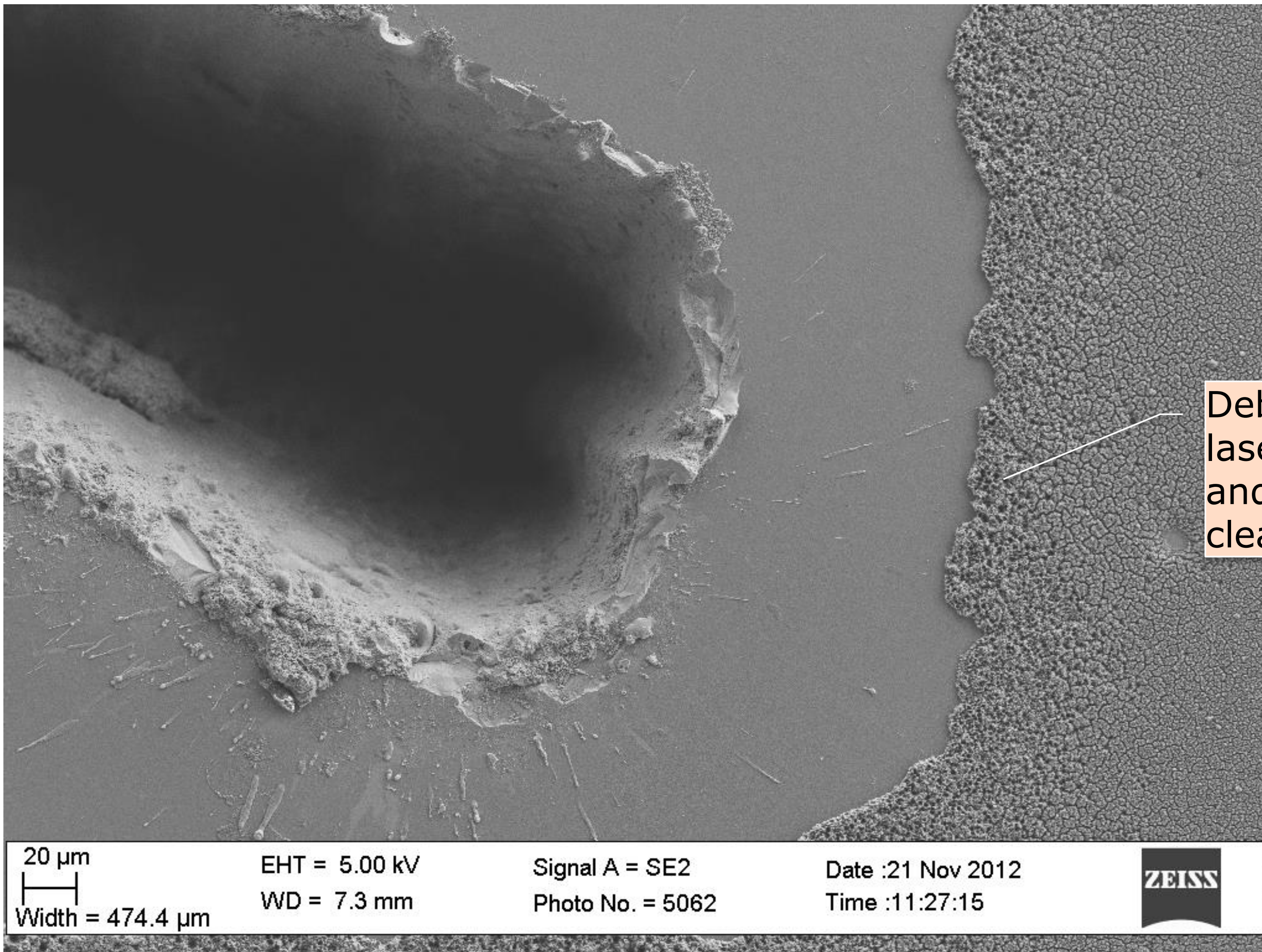
Dicing Silicon



Mainly to be used for cutting odd shapes in silicon.

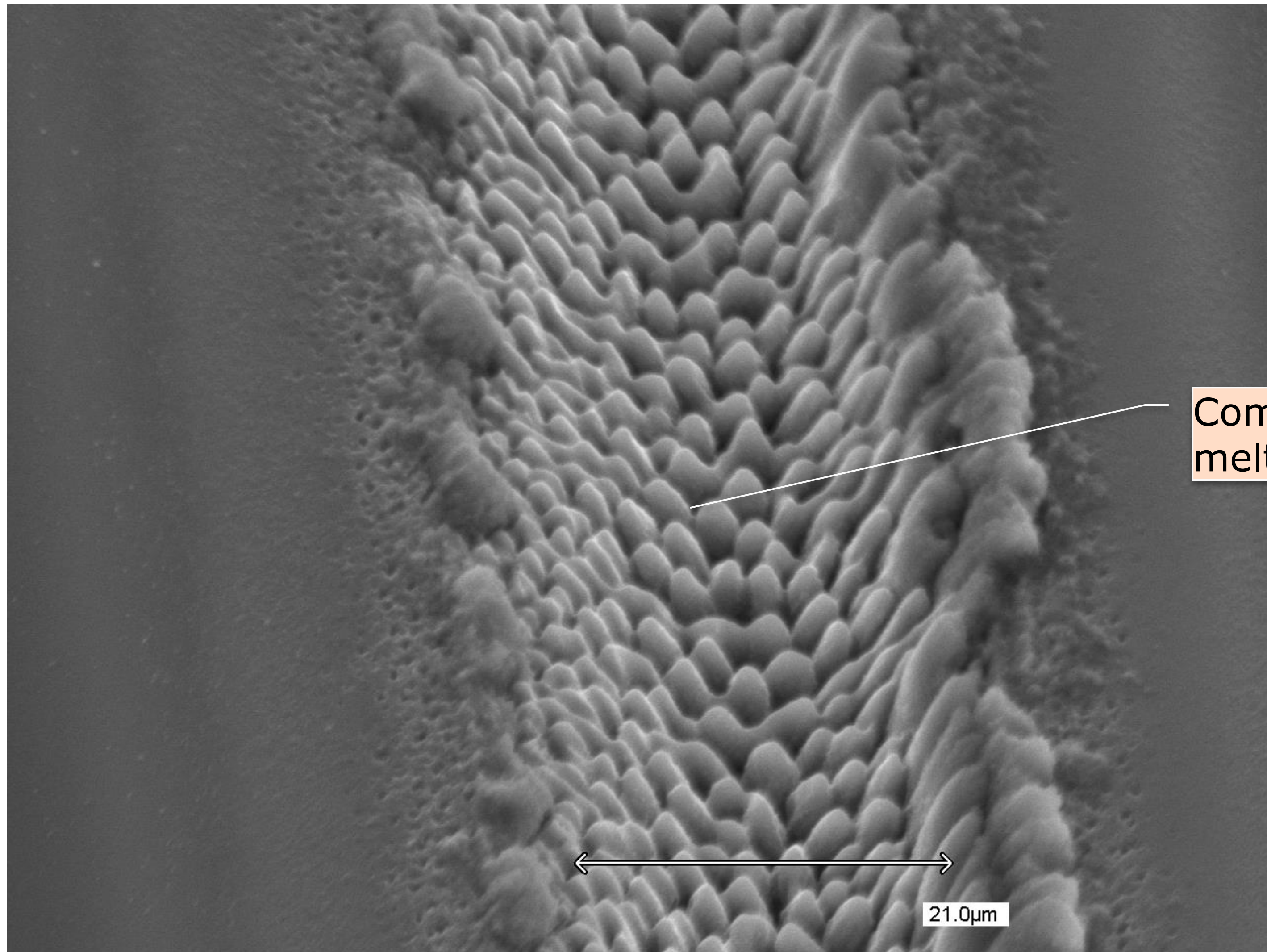
Like this…

Dicing Silicon



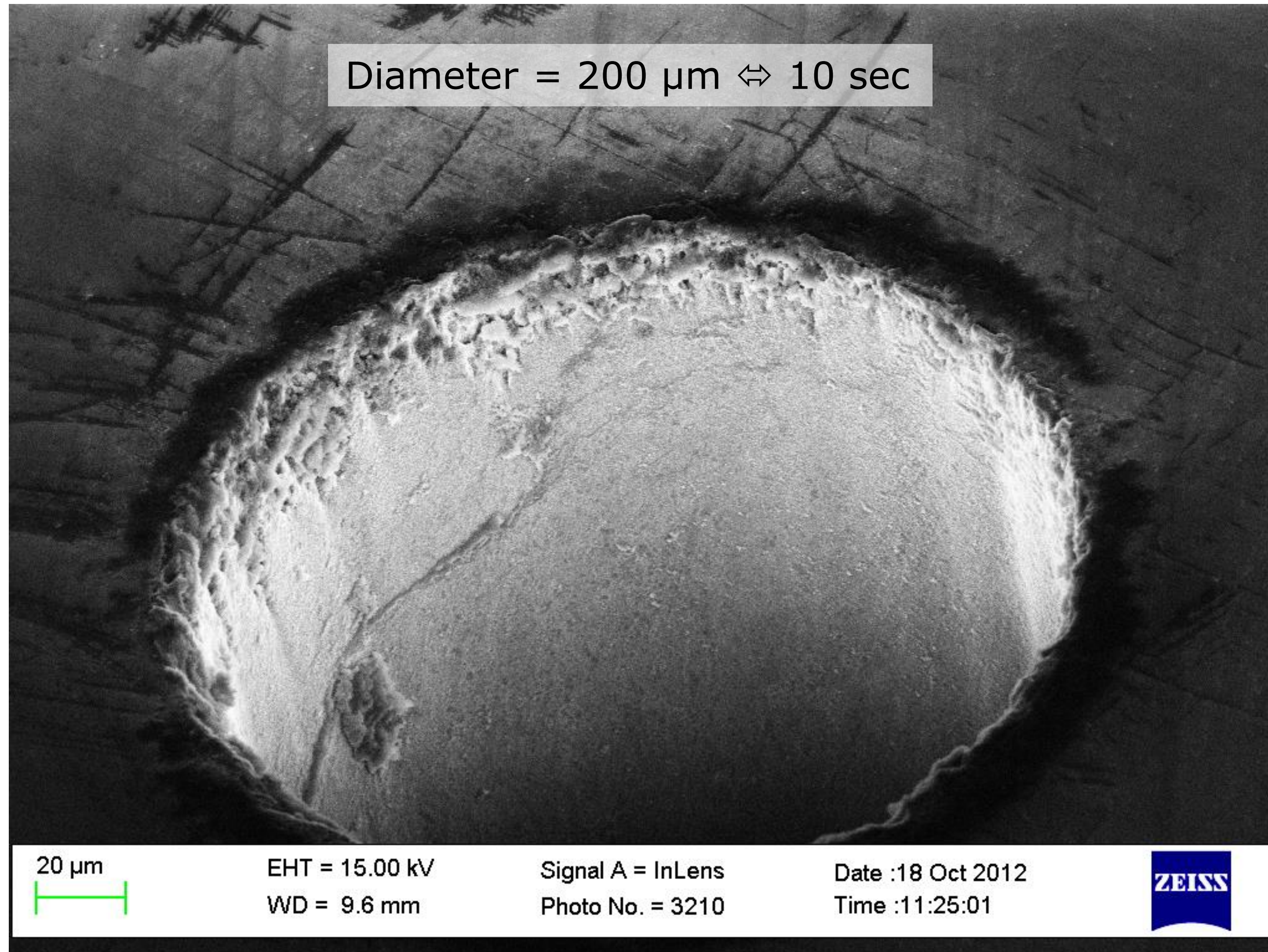
Debris after laser cutting and UltraSonic cleaning

Dicing Silicon



Comes from melted silicon

Hole Drilling in Silicon



Dicing Silicondioxide (on silicon)

10 µm layer SiO_2

15 cm ⇔ 34 sec

260 µm

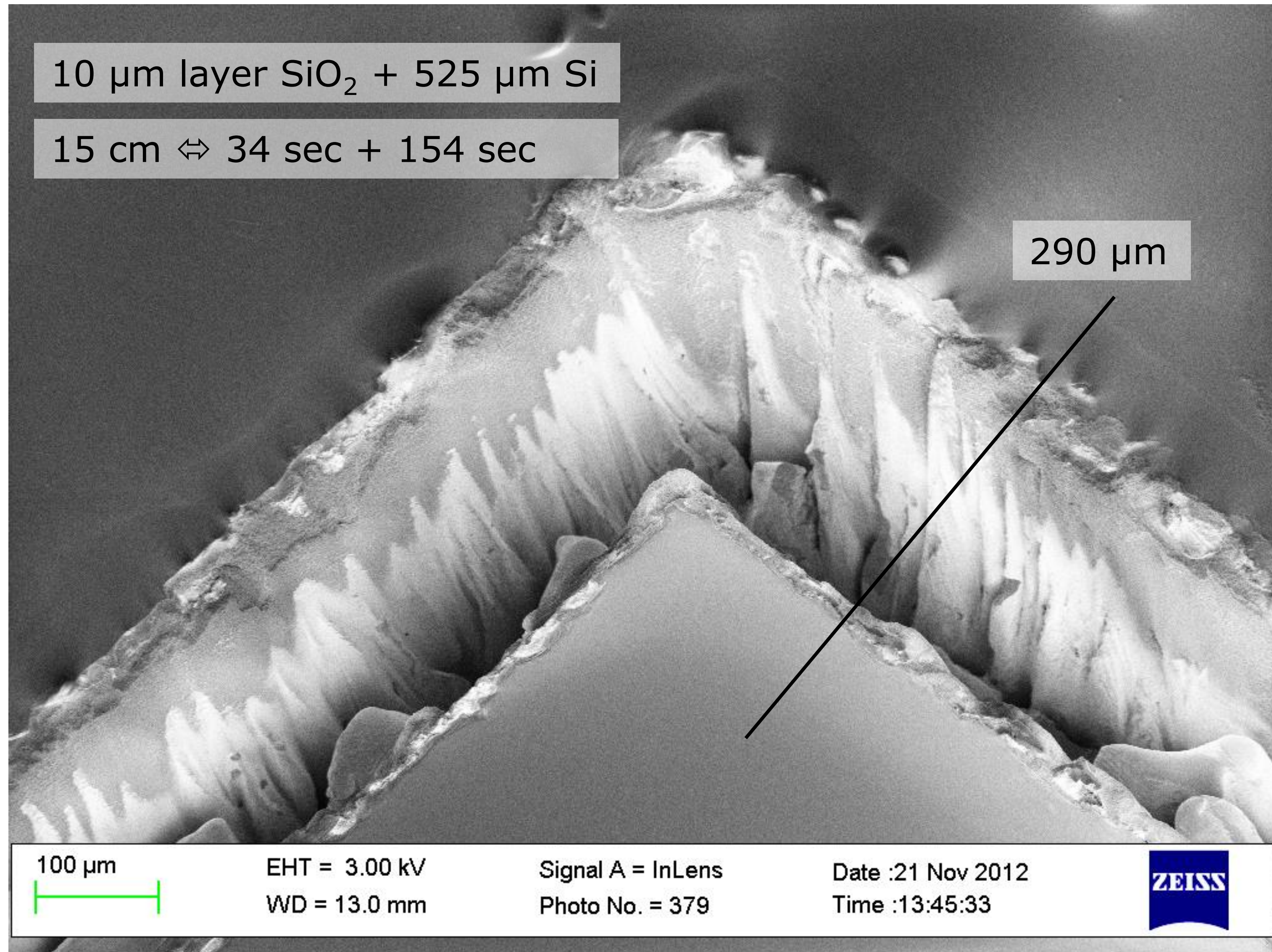
100 µm

EHT = 3.00 kV
WD = 8.6 mm

Signal A = InLens
Photo No. = 390

Date :21 Nov 2012
Time :14:13:54

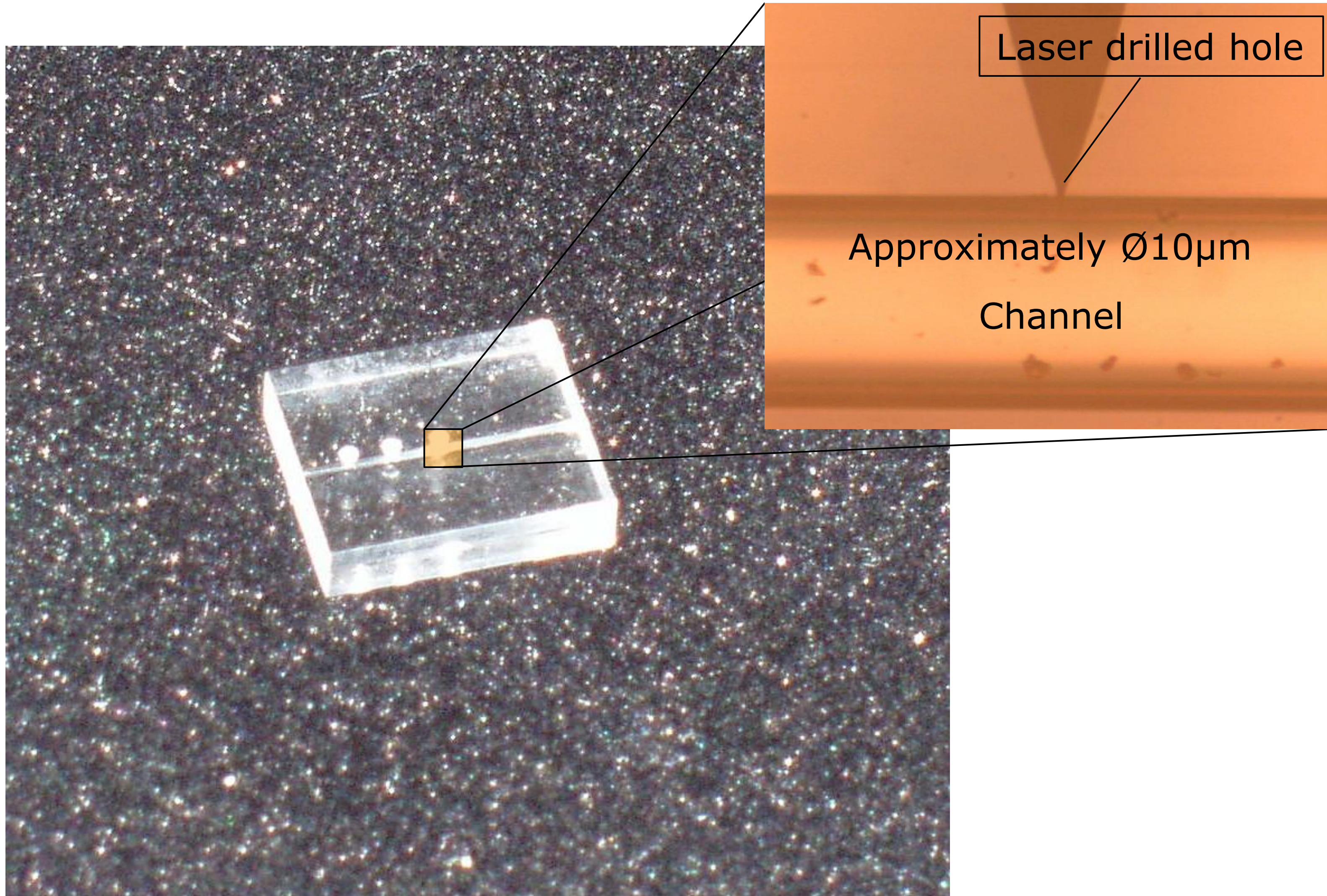
Dicing Silicondioxide and Silicon



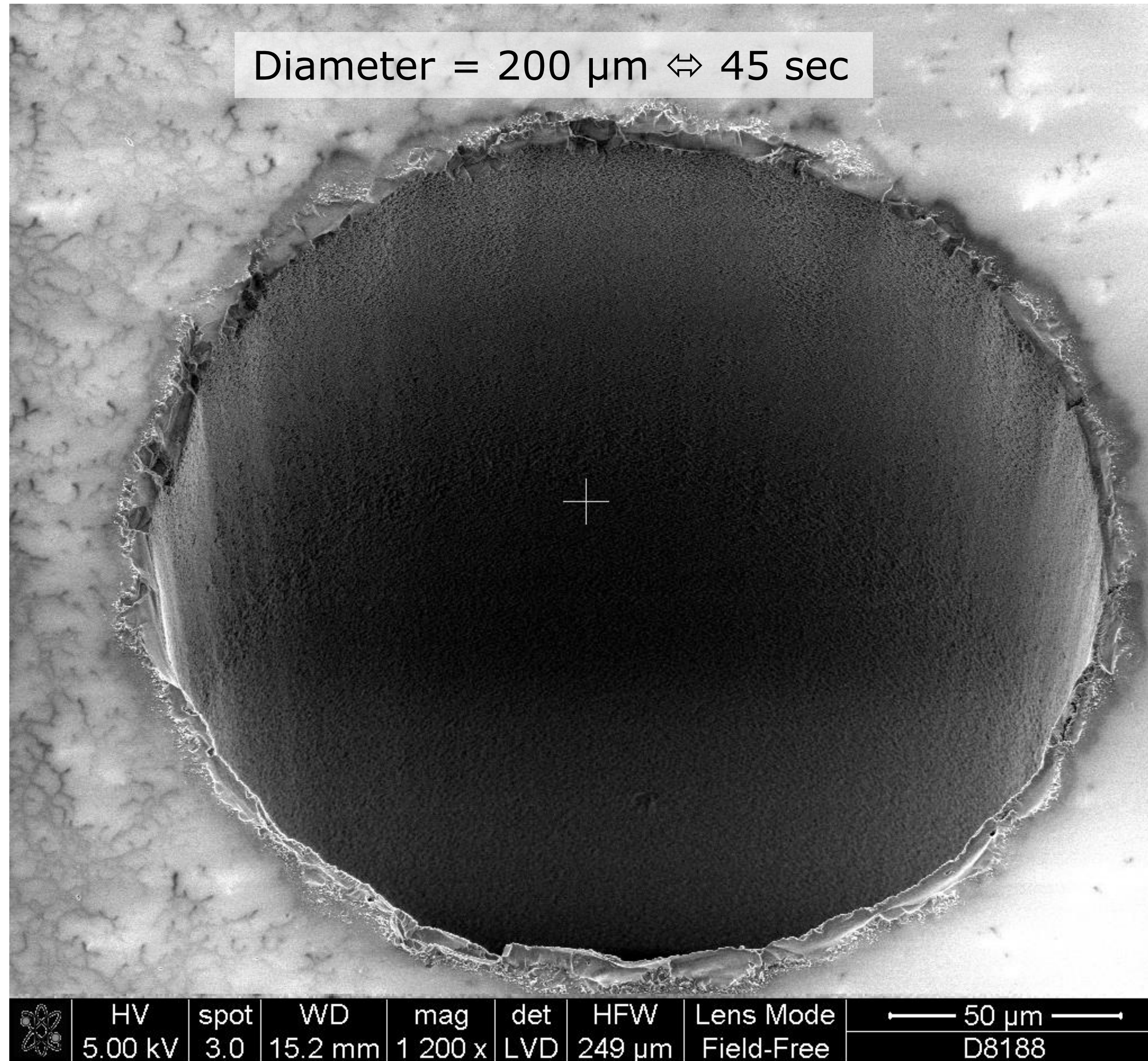
Dicing Fused Silica

500 µm / 10 cm ⇔ 78 sec

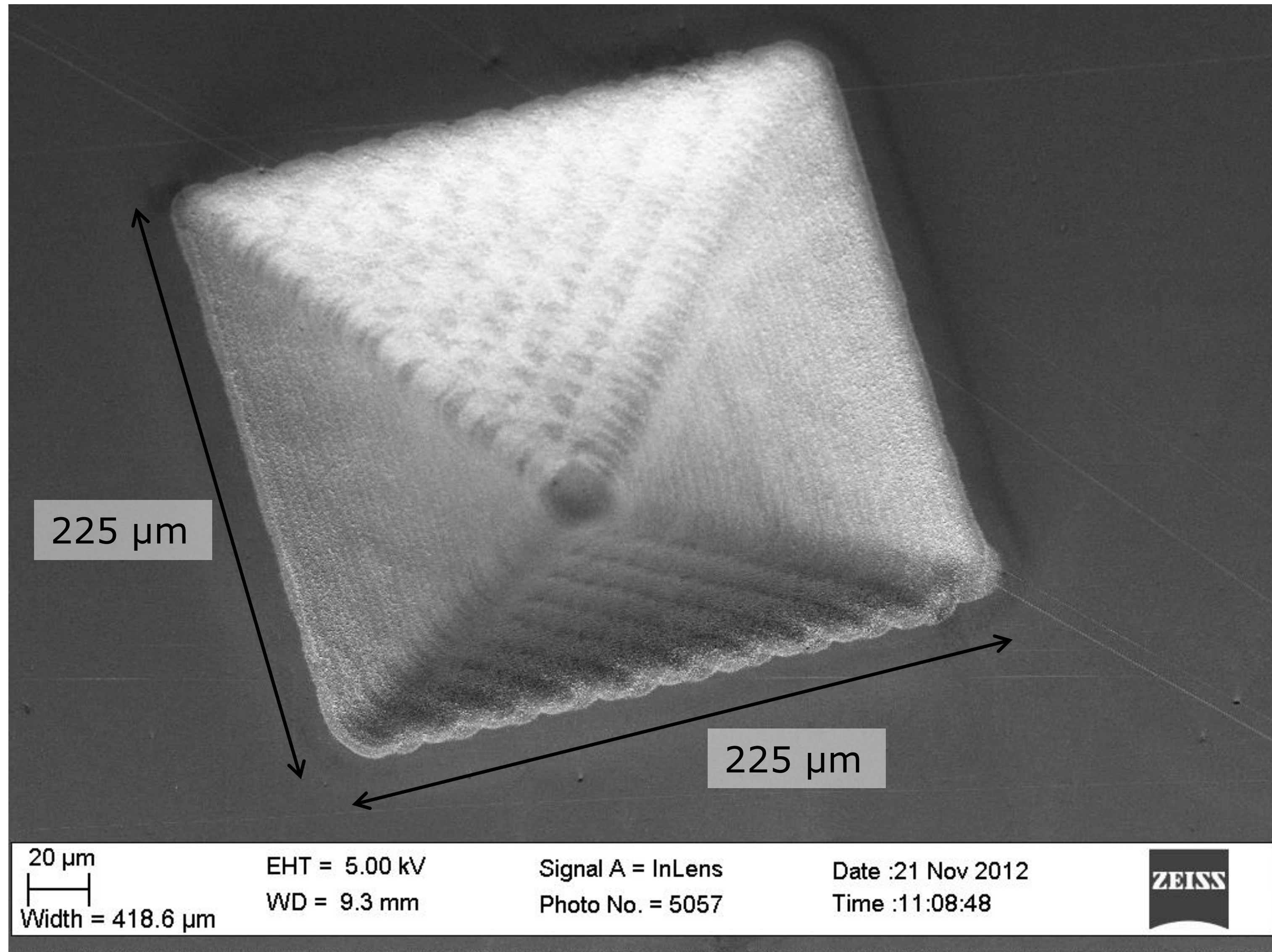
Drilling very small holes in borofloat glass



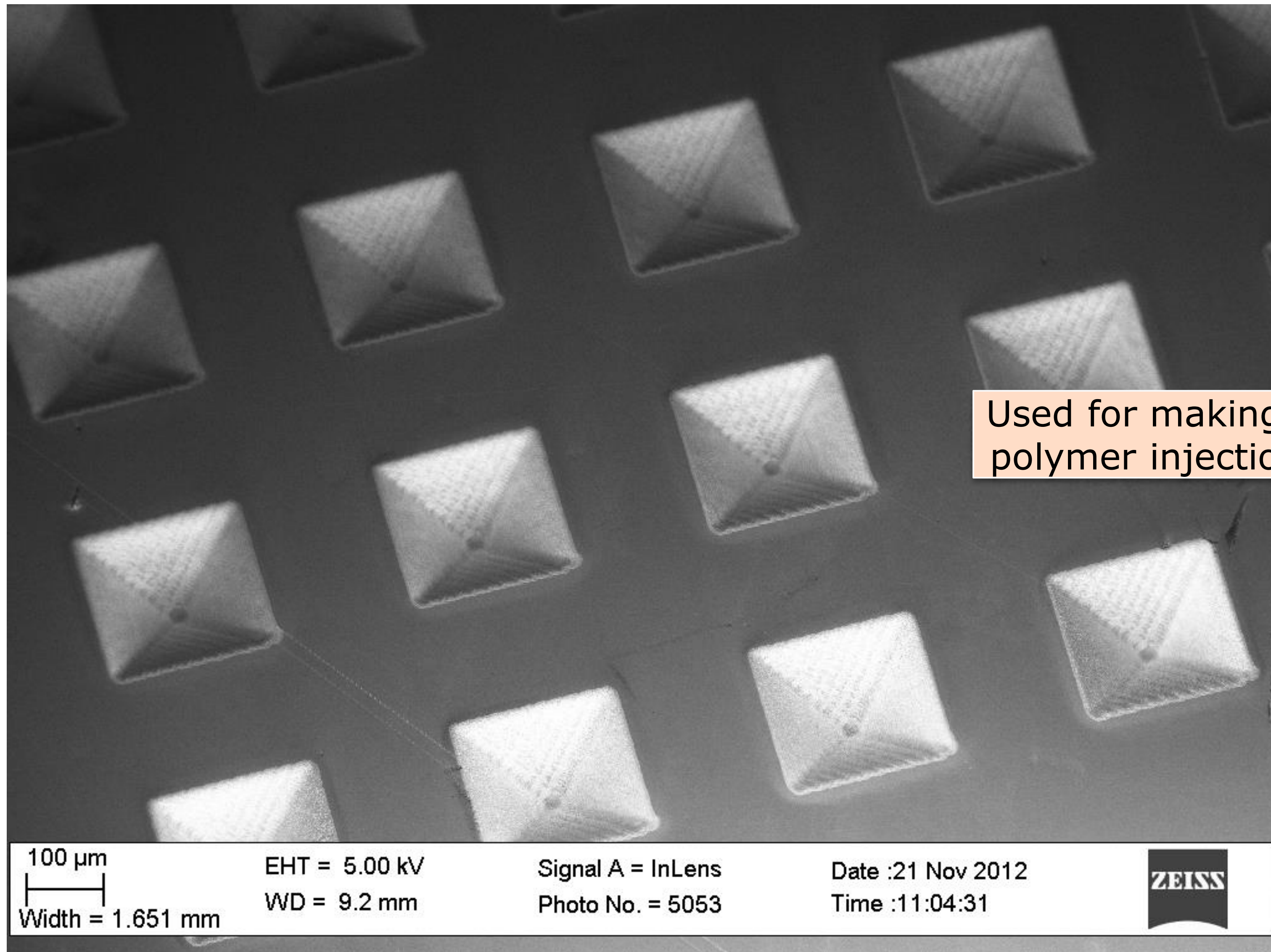
Larger holes in Borofloat



3D Microstructuring of Nickel

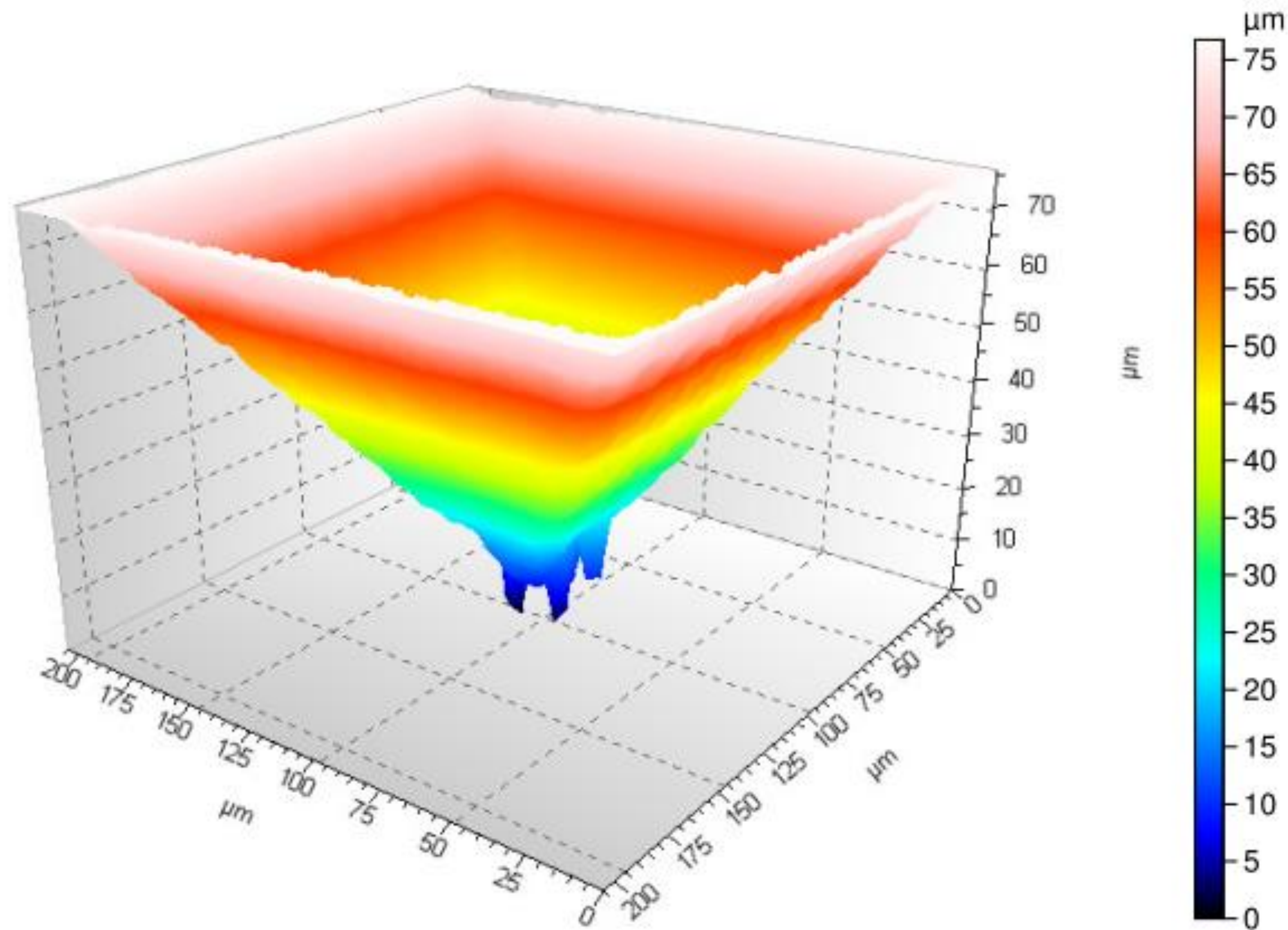


3D Microstructuring of Nickel

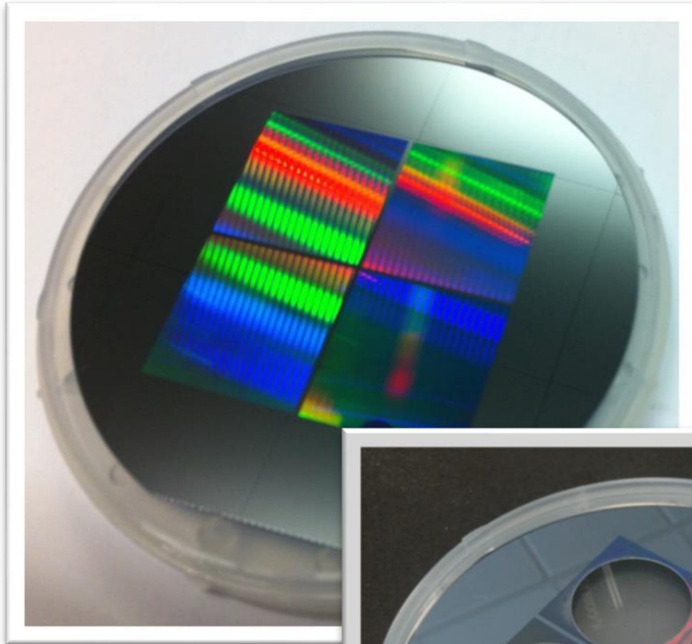


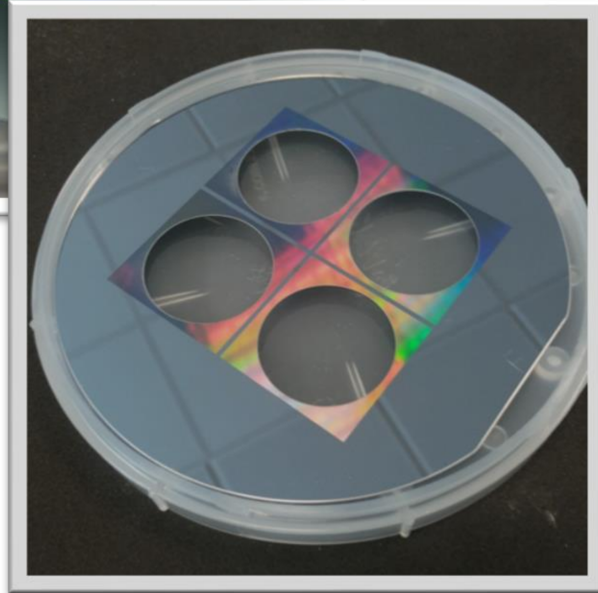
Used for making shim for polymer injection molder

Microstructuring Nickel



Dicing patterned silicon





Customer : René Bergmann

Shadow mask

Customer : Anil Haraksingh Thilsted

400μm thick aluminum

TEM holder for nitride membrane

Customer : Eric Jensen

Using the Laser Micromachining tool at Danchip

PRACTICAL INFORMATION

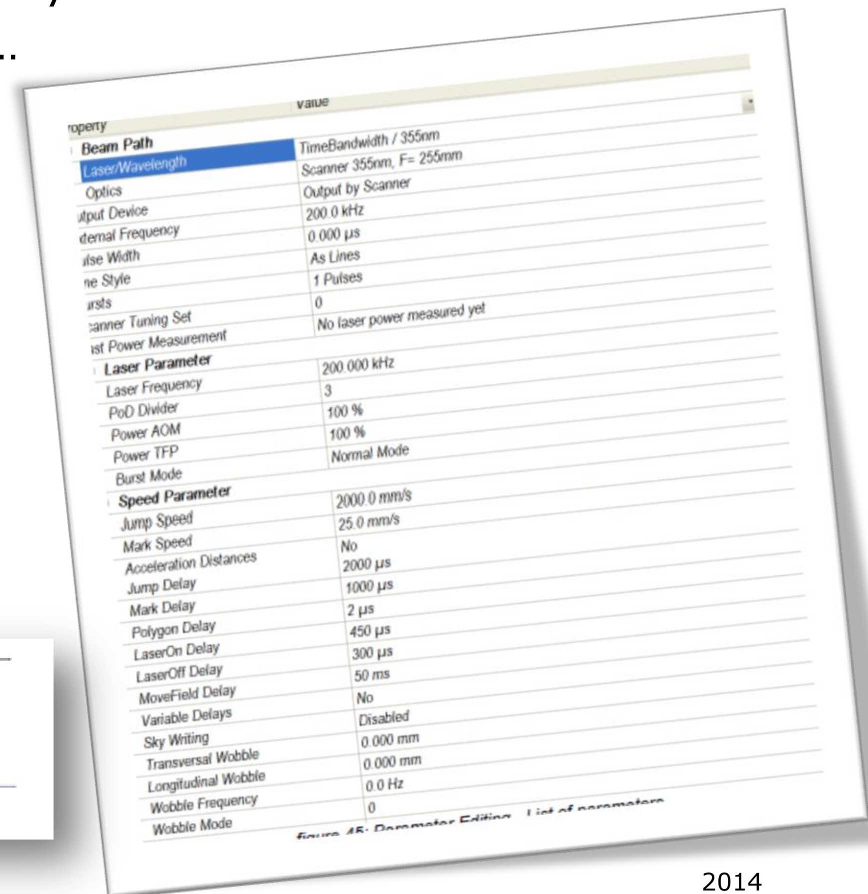
Sign up for training

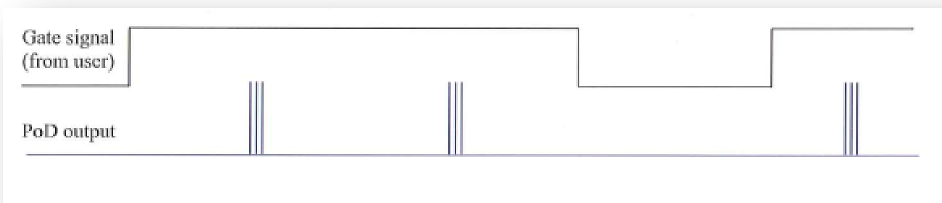
- Write to training@danchip.dtu.dk
- Please describe what you want to do
  - Material
  - Dimensions
  - Cutting, milling or drilling holes?
  - If possible enclose drawing
- Training requires 2 sessions of approximately 2 hours

Processing parameters

- We have some basic knowledge/experience on processing parameters for some materials
- Process optimization is your responsibility
  - but we would appreciate feedback…

- Many parameters to optimize on…
  - Power
  - Writing speed
  - Repetition frequency
  - Pulse burst mode/picking
  - Iterations
  - Focus
  - …





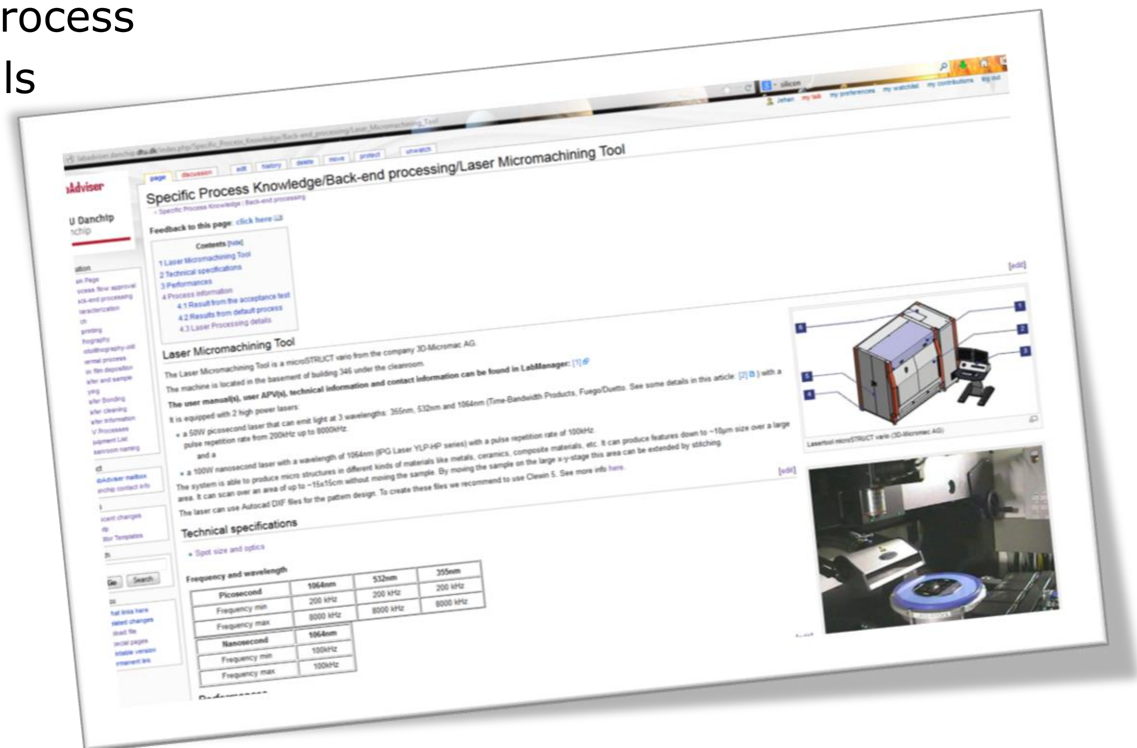
Information on LabAdviser

- Technical specifications
- Performance
- Process information
  - Result from the acceptance test
  - Results from default process
  - Laser Processing details

<u>Find it under:</u>

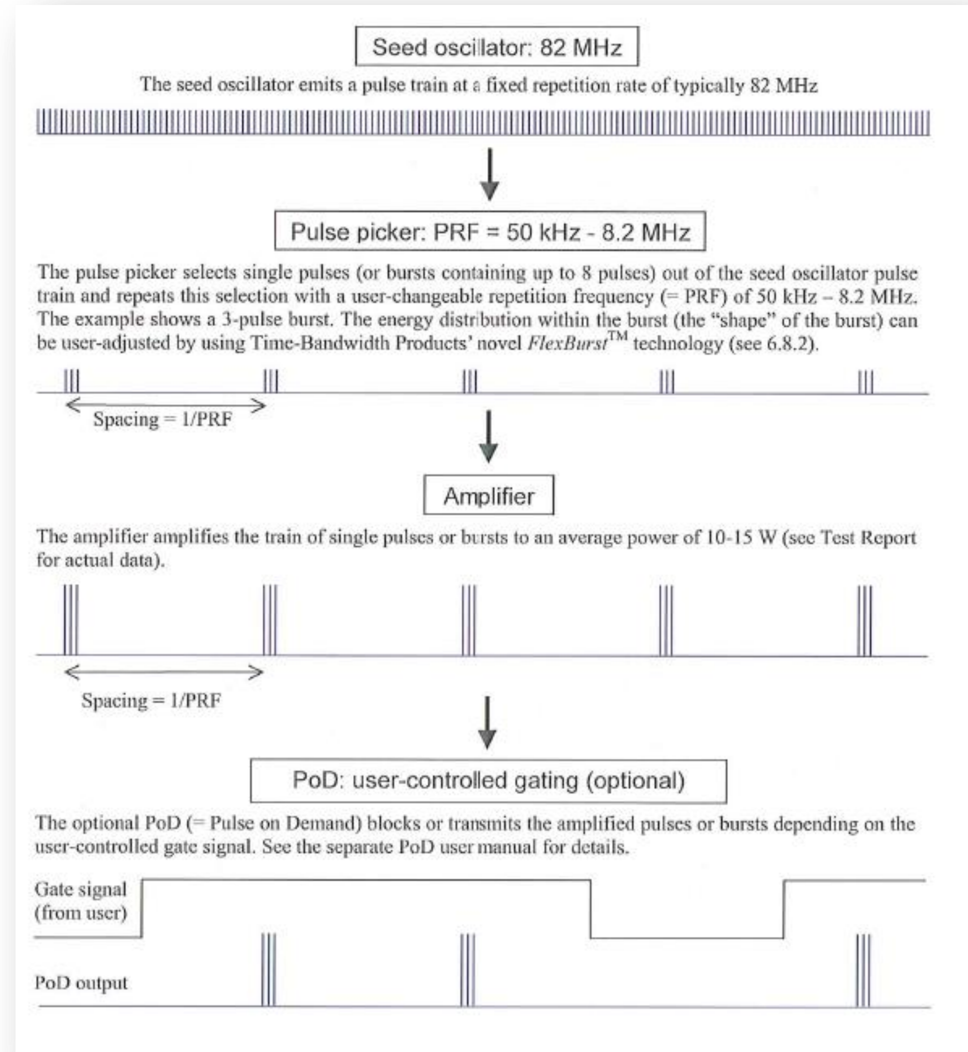
Back-end processing/

Laser Micromachining Tool



Picosecond Laser operation

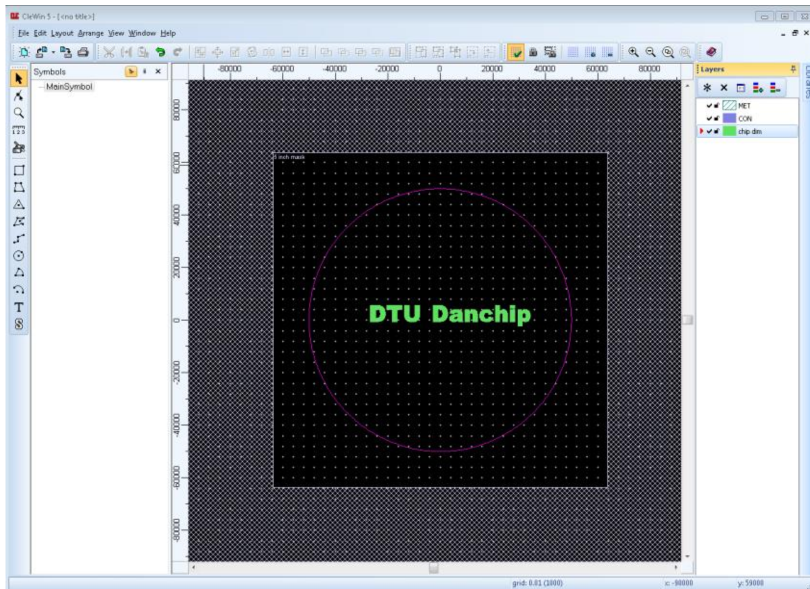
- Time Bandwidth – Duetto



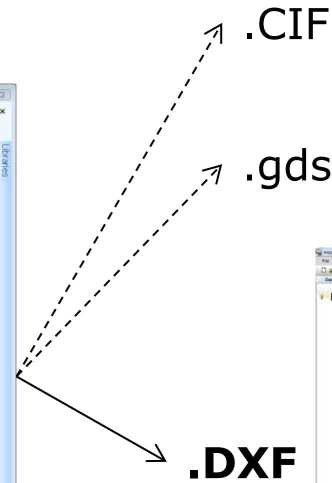
How to design a pattern ?

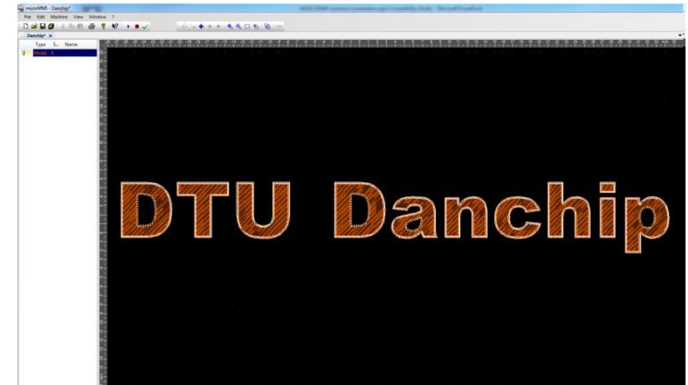
DESIGN

Design graphical pattern for laser software



CleWin 5.1 - interface

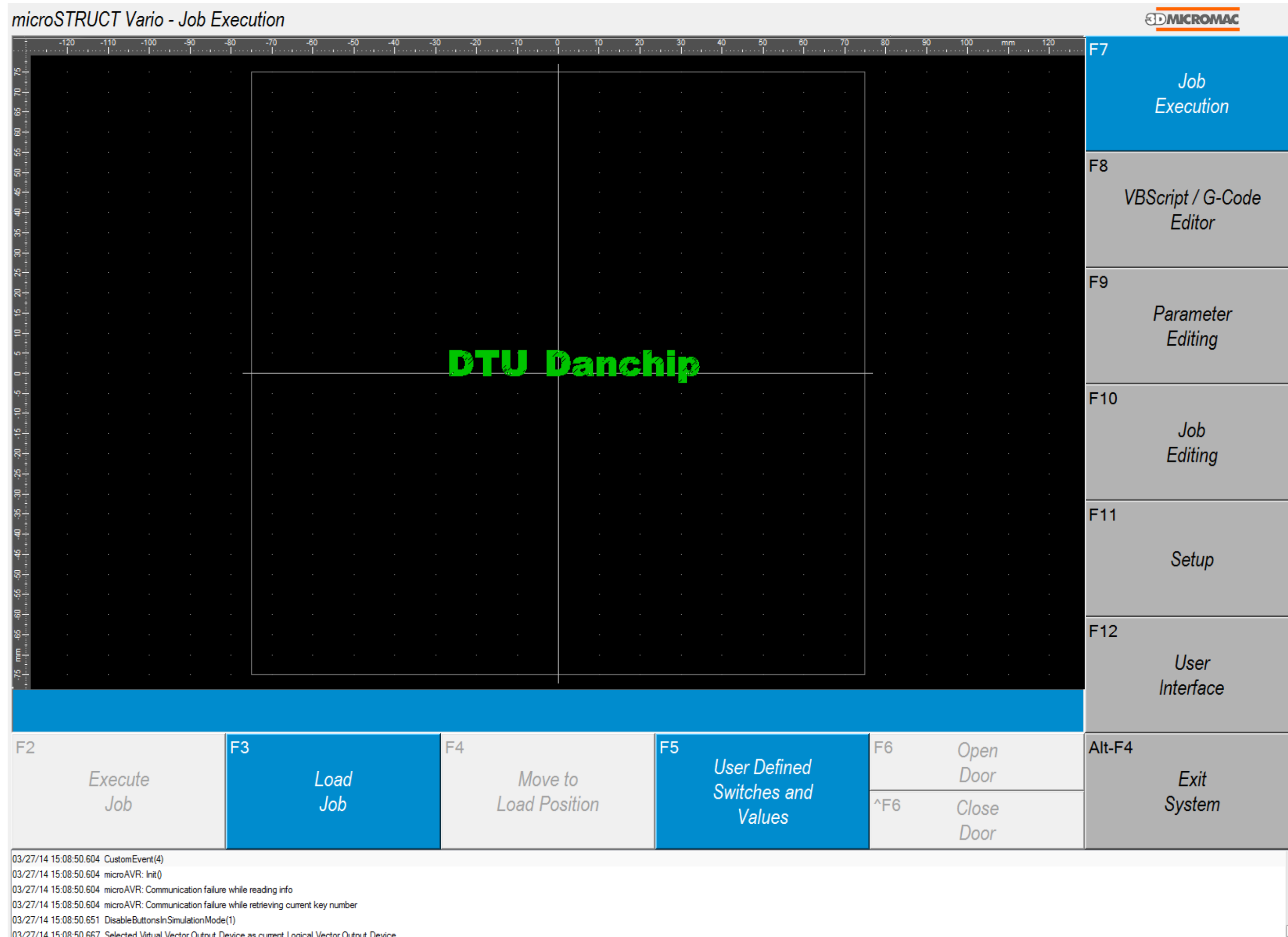




microMMI – interface software

.CONX

Design graphical pattern for laser software



microMMI Automation- interface

Design script pattern for laser software

microSTRUCT Vario - VBScript Editor

3D MICROMAC

F7 Job Execution

F8 VBScript / G-Code Editor

F9 Parameter Editing

F10 Job Editing

F11 Setup

F12 User Interface

F2 Create new VBScript

F3 Load VBScript

F4 Save VBScript

^F4 Save VBScript as...

F5 Toggle Editor/Preview

F6

Alt-F4 Back

8µm 16µm 24µm 32µm 40µm 48µm 56µm 64µm

90 deg