

Purification and Crystal Growth at IKZ

W. Miller
Leibniz Institute for Crystal Growth (IKZ)



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Process Line at IKZ

Raw material: Germanium 9N



Purification by zone melting

Ge 9N $\Rightarrow$ Ge 12N



Czochralski growth

2" single crystals, 3" single crystals



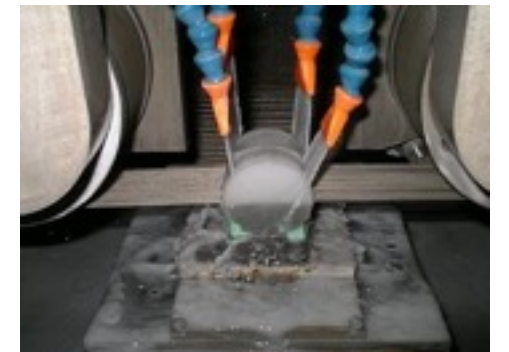
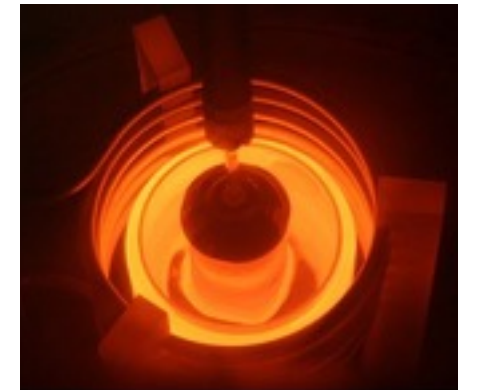
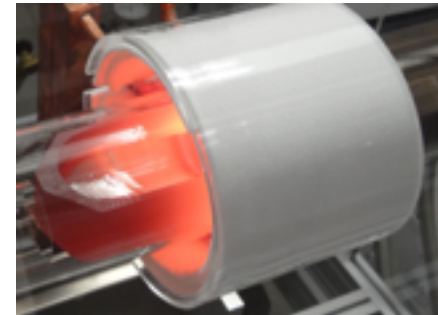
Crystal machining (cutting, polishing, ...)

blocks, wafers,



Characterization

EPD, LST, PL, PTIS, Hall, ...



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Czochralski Growth - Timeline

EKZ 2000 growth machine

- Modernized 2010
- 5.3. 2010 first growth experiment
- February 2011
further measures for impurity shielding

impurity level too high !
H₂ instead of Ar required !

new machine by
in-house construction 

RGZ growth machine

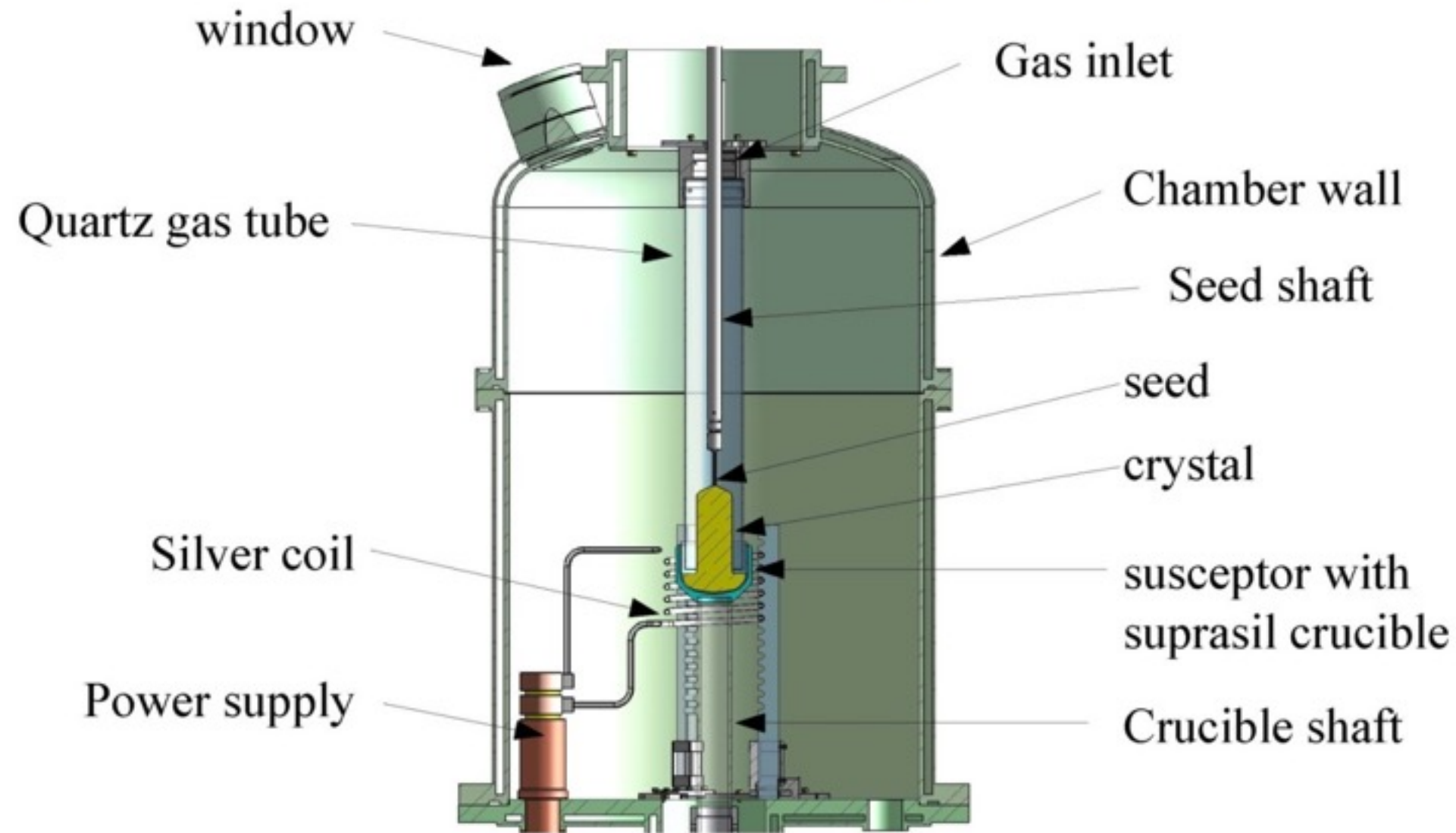
- installed Dez. 2013
- operating license May 2014
- operating with H₂ Nov. 2015



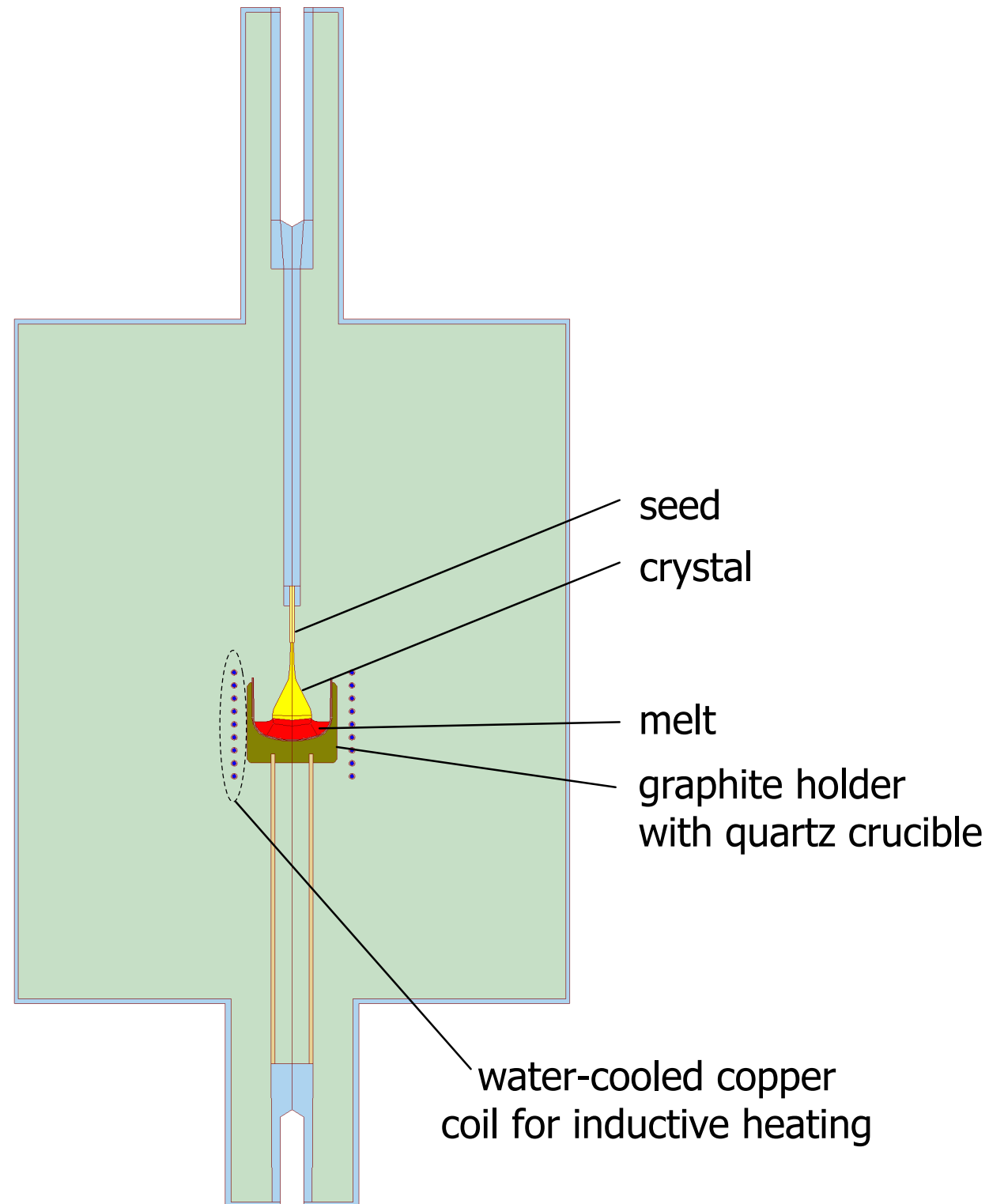
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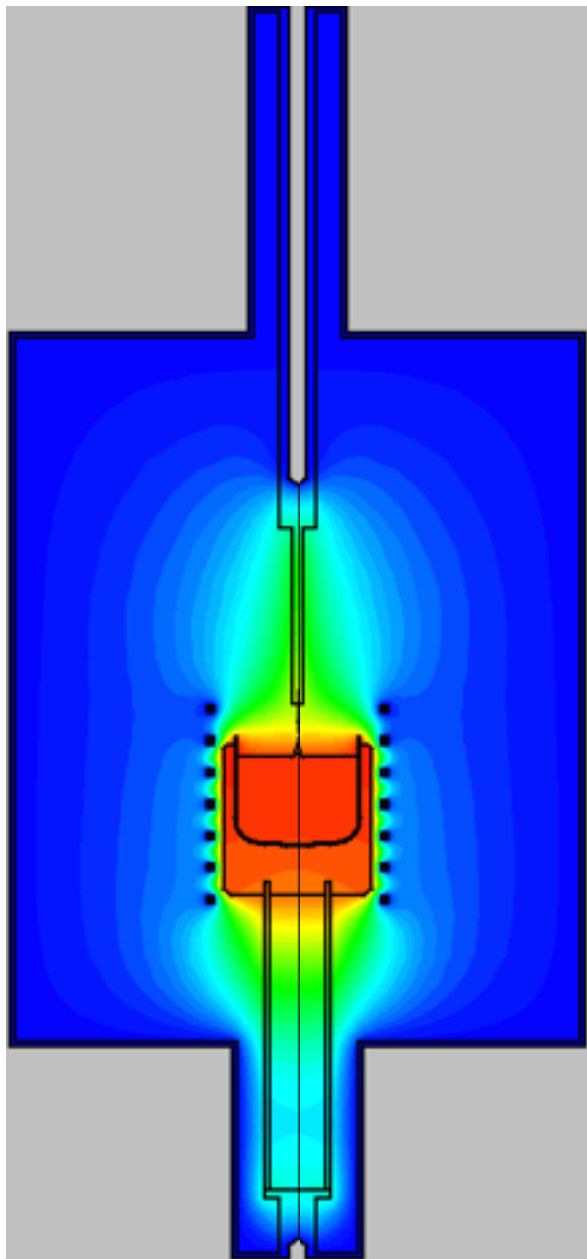
Czochralski Growth



Czochralski Growth



Czochralski Growth - Challenges



Few insulations &
inductive heating

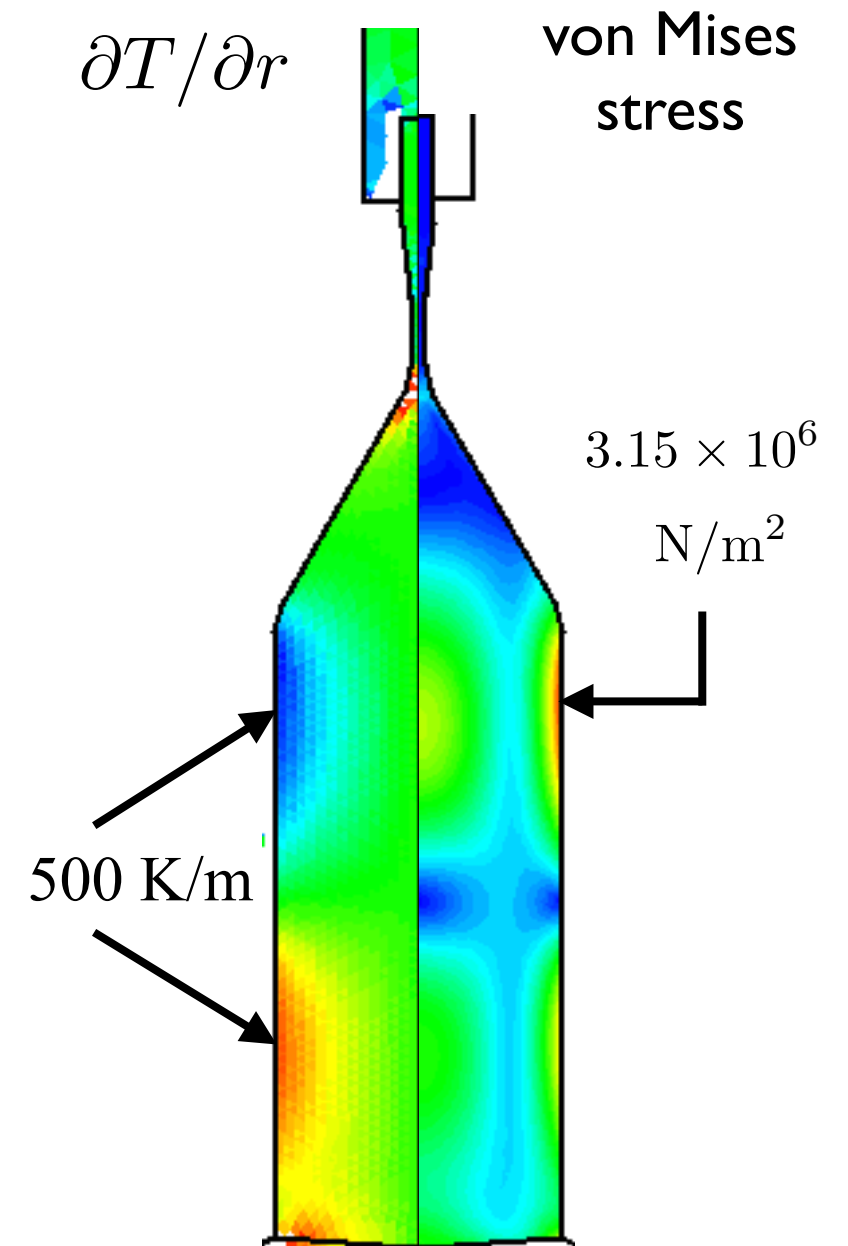
➡ high temperature gradients

➡ high stress

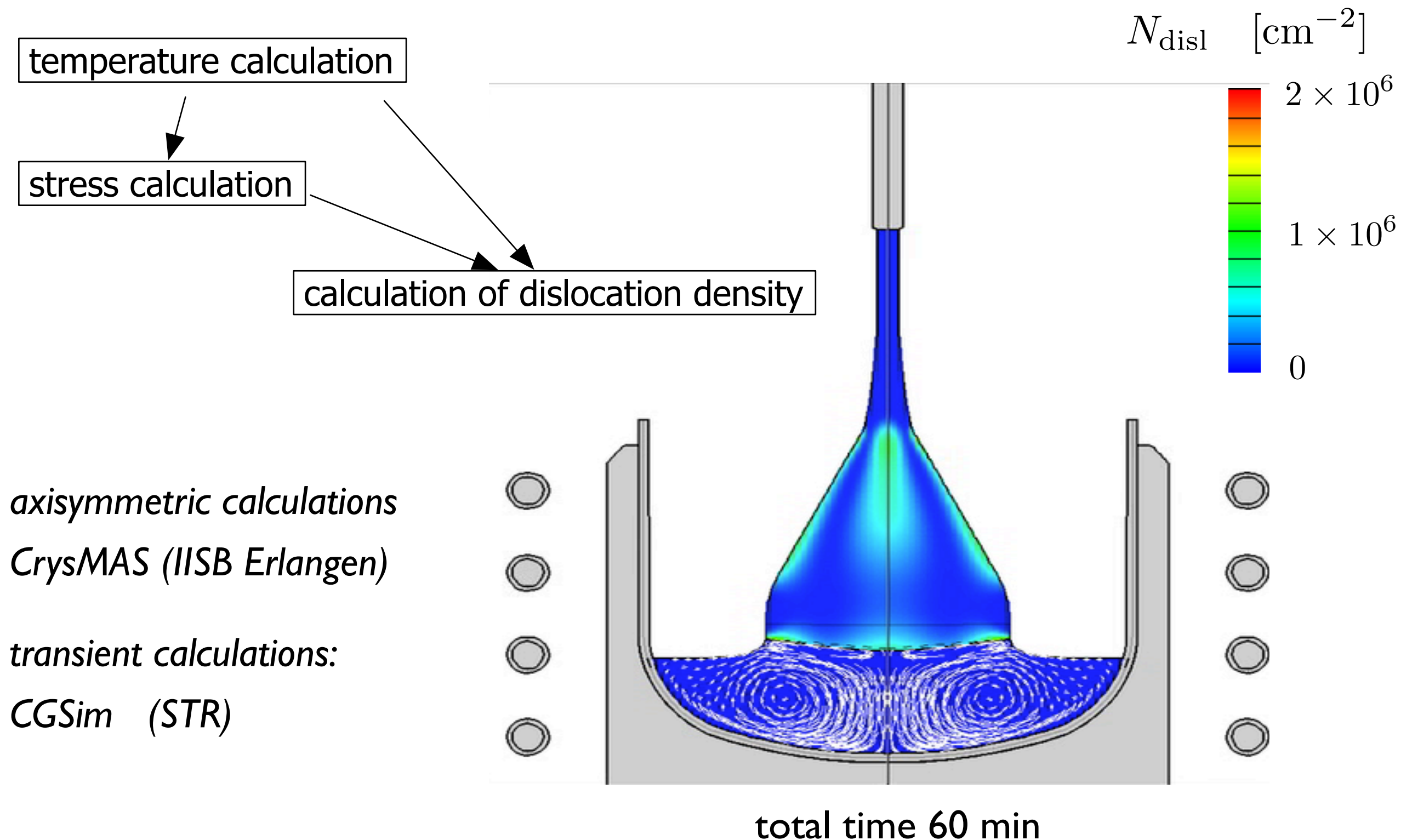
➡ many dislocations

✗ for better understanding
and improving:

numerical calculations

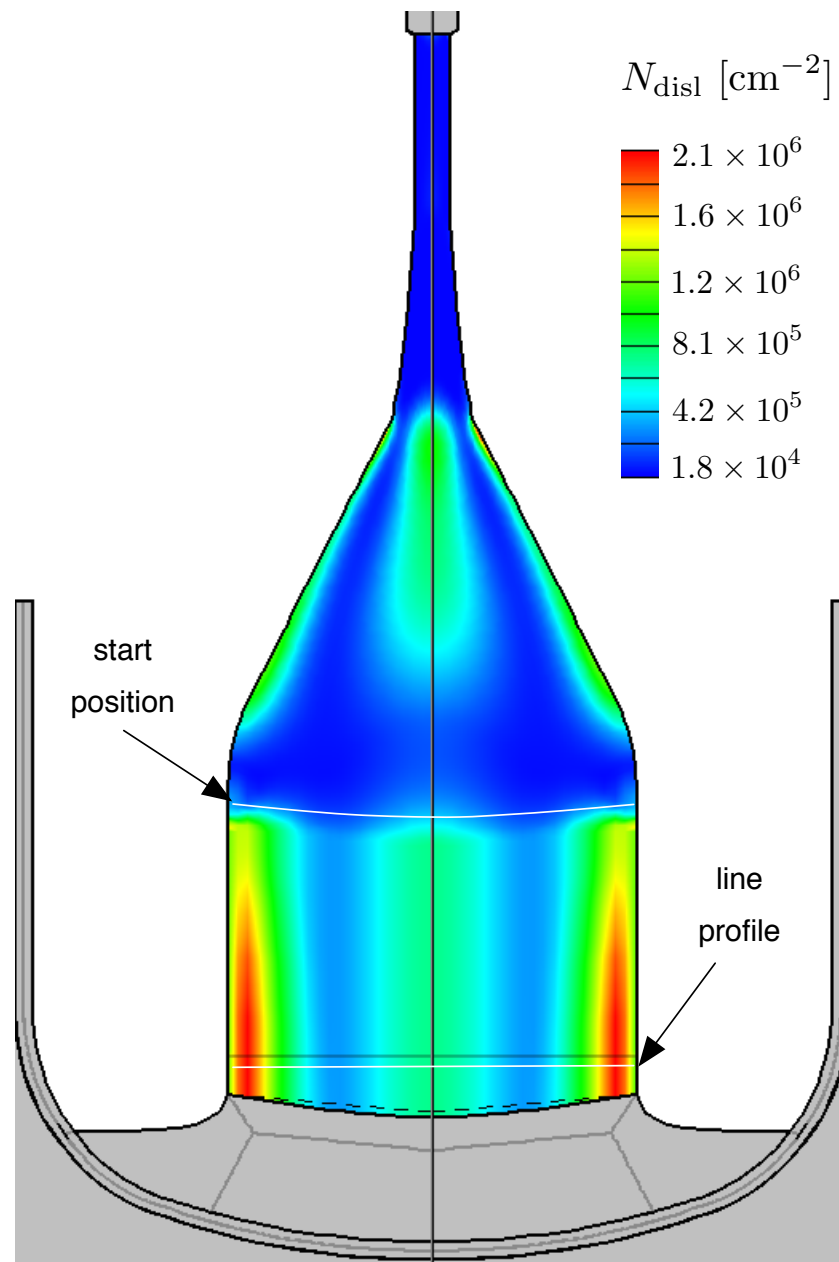


Numerical Modelling

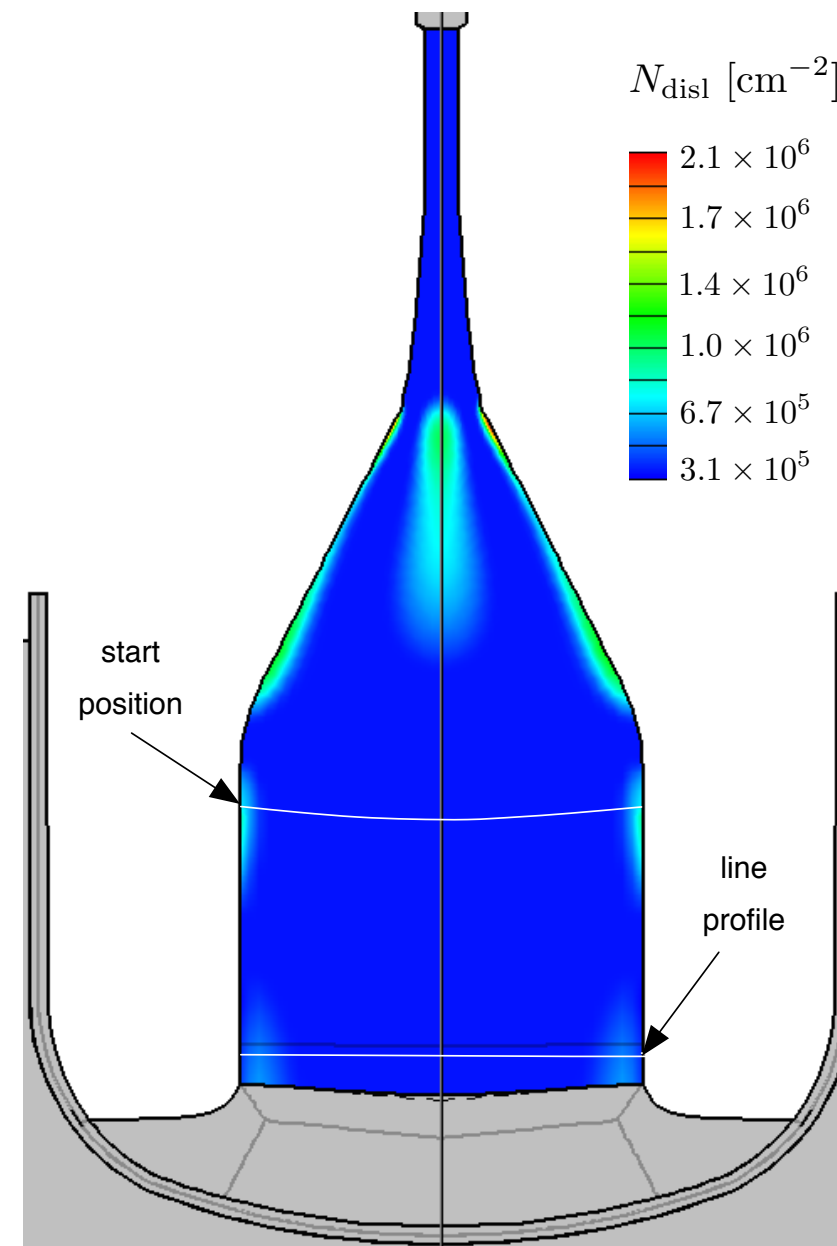


Numerical Modelling

A) crystal rotation rate 15 rpm
crucible rotation rate -5 rpm



B) crystal rotation rate 20 rpm
crucible rotation rate -2 rpm



Experiments

Crystal rotation rate
Crucible rotation rate

15 rpm
-5 rpm

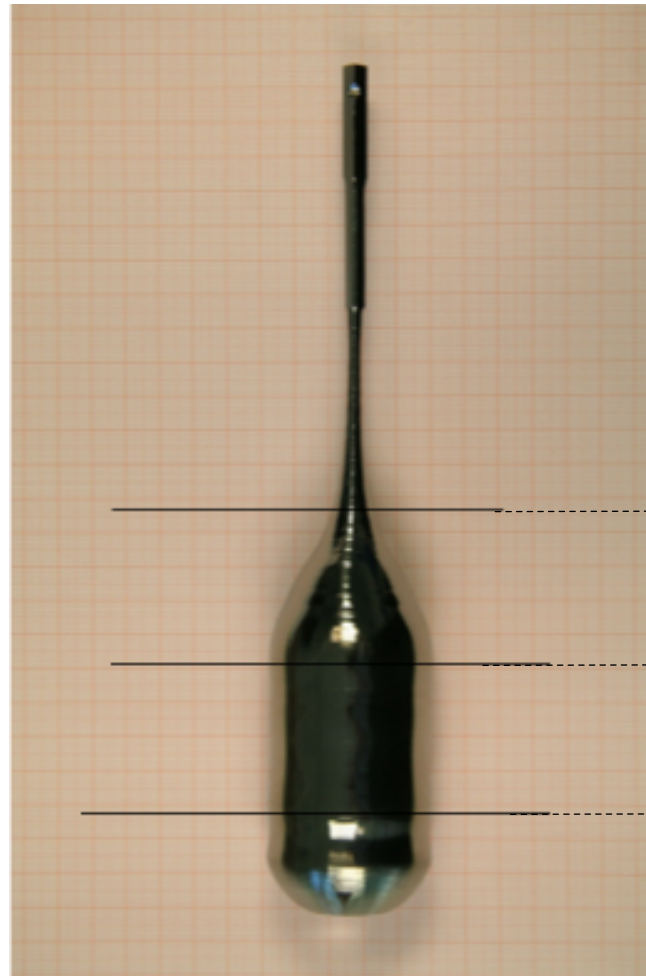
20 rpm
-2 rpm

$N_{\text{disl}} \quad [\text{cm}^{-2}]$

$1 - 2 \times 10^4$

$1 - 2 \times 10^5$

$0.7 - 1.1 \times 10^5$



$N_{\text{disl}} \quad [\text{cm}^{-2}]$

$2.7 - 3.9 \times 10^5$

$3.1 - 4.3 \times 10^5$

$2.0 - 2.9 \times 10^5$

**Problem: N_{disl} already high at neck !
melt surface not clean enough**

1st Experiment in H₂



$N_{\text{disl}} \quad [\text{cm}^{-2}]$

0

$1.9 - 2.8 \times 10^4$

$1.2 - 7.7 \times 10^4$

Crystal rotation rate
Crucible rotation rate

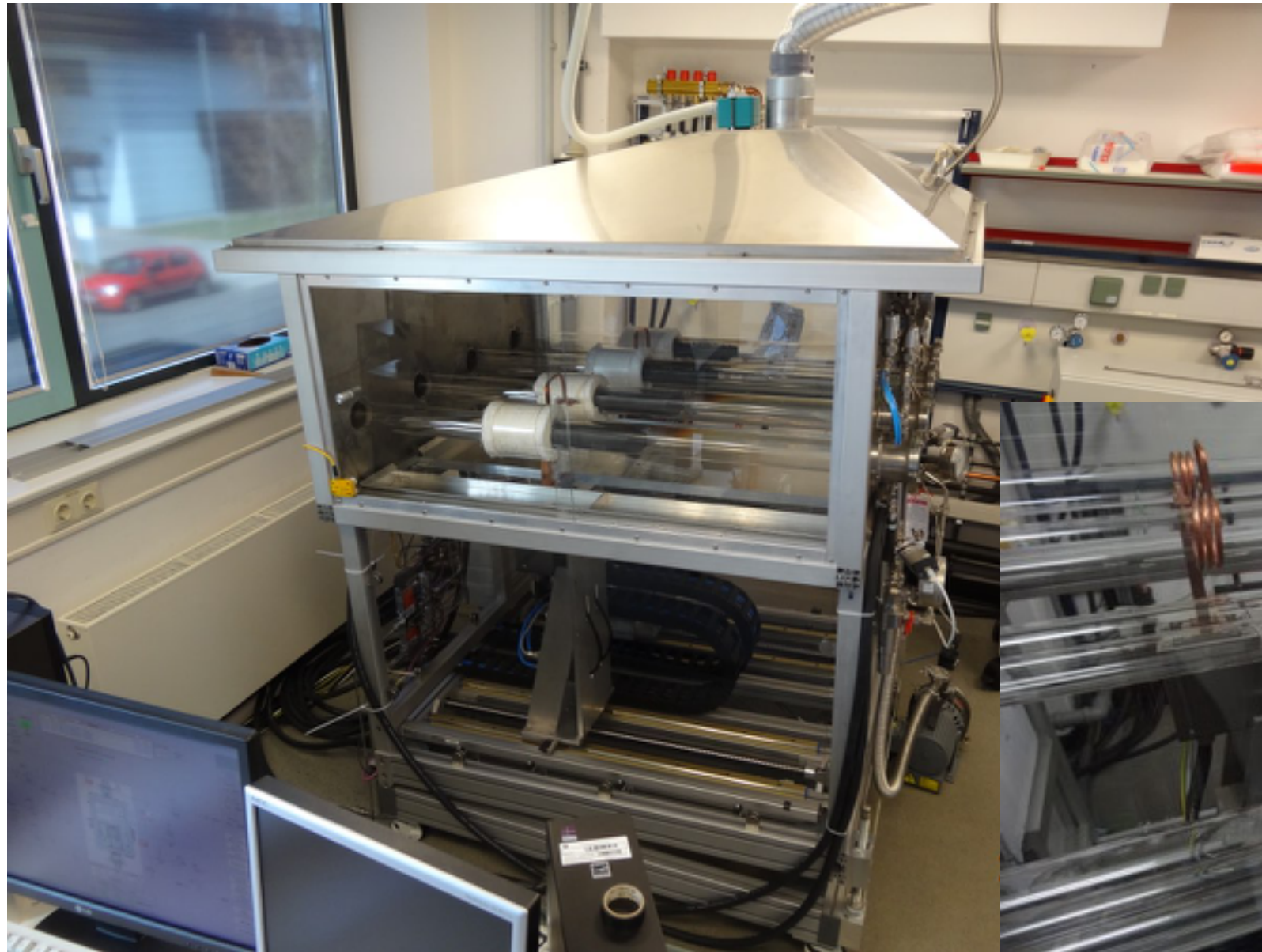
20 rpm
-2 rpm

N_{disl} about a
magnitude smaller

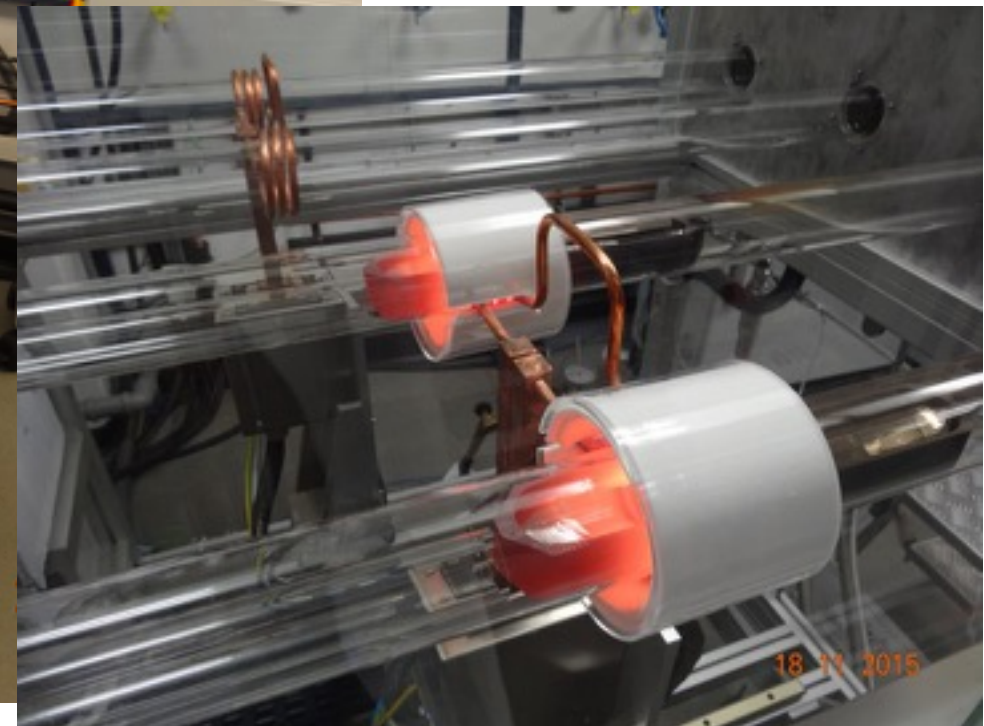


Purification by multi zone melting

four tubes - fully automatically operating



Operating license
obtained at
15th April 2016



Test runs in progress



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Czochralski Growth



Runs for systematic study of dislocation densities in combination with numerical simulations.

Adjusting extra features to reduce dislocation densities



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Conclusions

- ➡ Full line is in operation now
- ➡ Purification will be tested
- ➡ Czochralski growth in H_2 will be systematically studied and improved



Team Members

1	Nikolay Abrosimov	●	head of team
2	Jörg Fischer	●	construction, purification & crystal growth
3	Matthias Czupalla	●	crystal growth
4	Sintja Weiß	●	purification & crystal growth
5	Till Turschner	●	process control
6	Dr. Wolfram Miller	●	numerical simulation
7	Dr. Uta Juda	●	characterization
8	Dr. Klaus Irischer	●	characterization
9	Martin Naumann	●	characterization
10	Mike Pietsch	●	characterization

Support by: Dr. H. Riemann • Dr. Ch. Frank-Rotsch • L. Lehmann • K. Reinhold
• T. Wurche • M. Imming • A. Kwasniewski, • M. Ziem • J. Klose



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