Specimen preparation and control over magnetic fields for CHIRALTEM experiments

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1. Creation of Fe specimens on GaAs membranes
2. Specimen preparation by FIB
3. Switching of objective lens current on Tecnai microscopes
4. Summary/Prospect

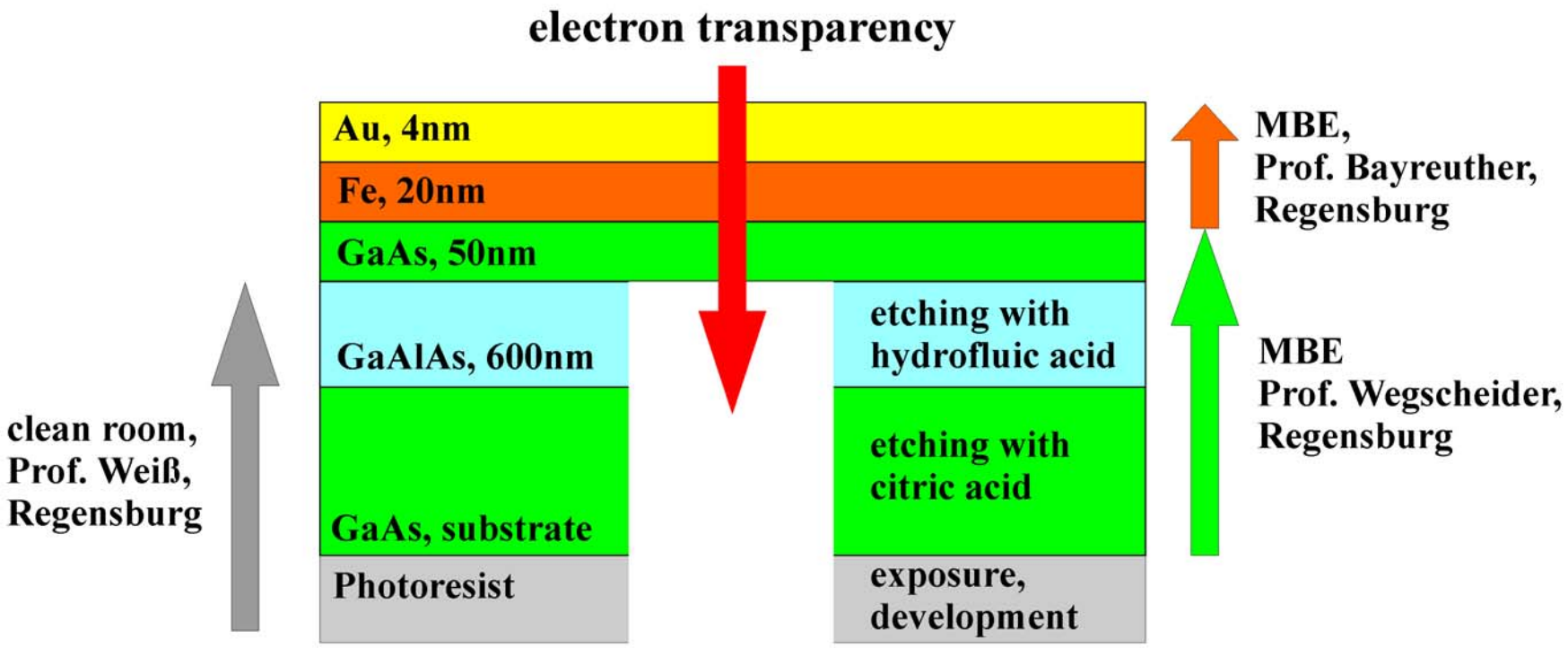
Motivation: requirements for CHIRALTEM specimens

The „ideal“ CHIRALTEM specimen has to be:

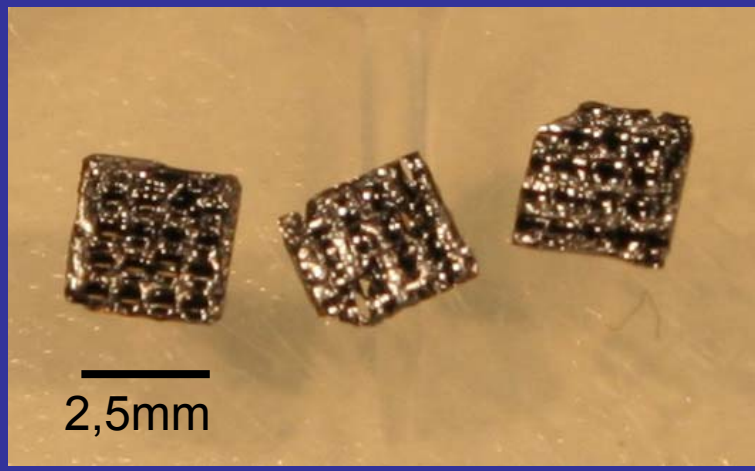
- electron transparent
- ferromagnetic
- single crystal
- without thickness variations
- without background (membranes, etc.)
- large enough for XMCD

1. Creation of Fe specimen on GaAs membrane

Epitaxial growth of Fe on electron transparent GaAs membrane



1. Creation of Fe specimen on GaAs membrane



Theory:

+ epitaxial growth

+ every desired Fe layer thickness possible

+ thickness variation only a few monolayers

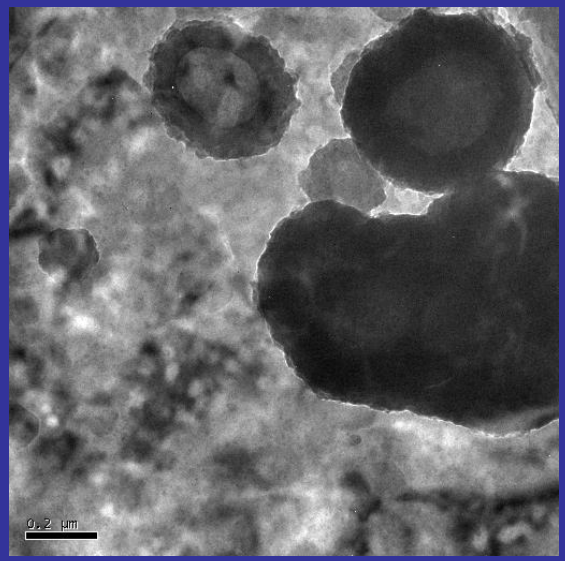
Reality:

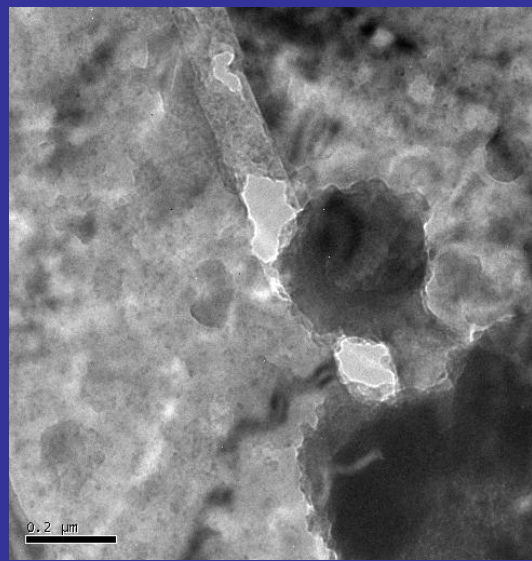
- huge variations in thickness of GaAs-membranes

- specimens very brittle, not transportable

- diffraction pattern of GaAs dominant

No specimens for CHIRALTEM!

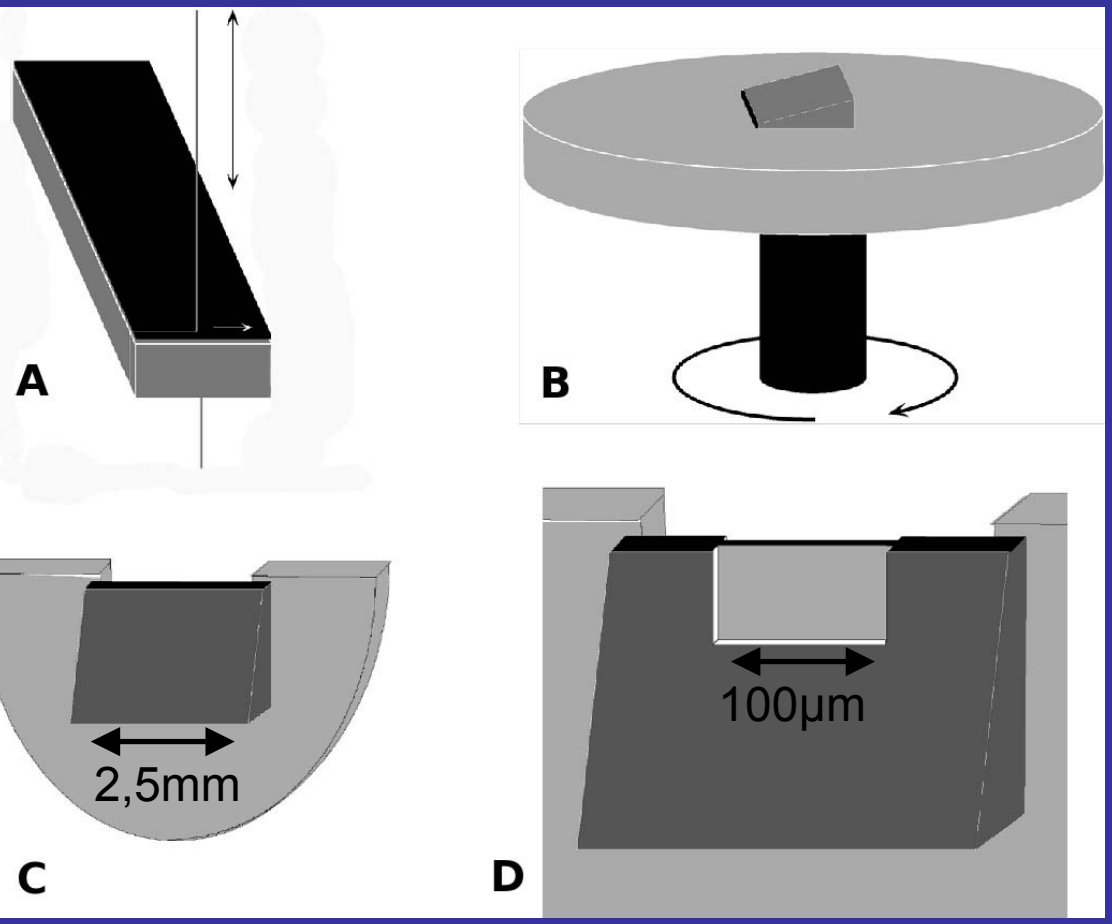




2. Specimen preparation by FIB

New attempt for CHIRALTEM specimen:

FIB preparation will be done in Bremen (Prof. Rosenauer, Dr. Kroeger)



Preparation steps:

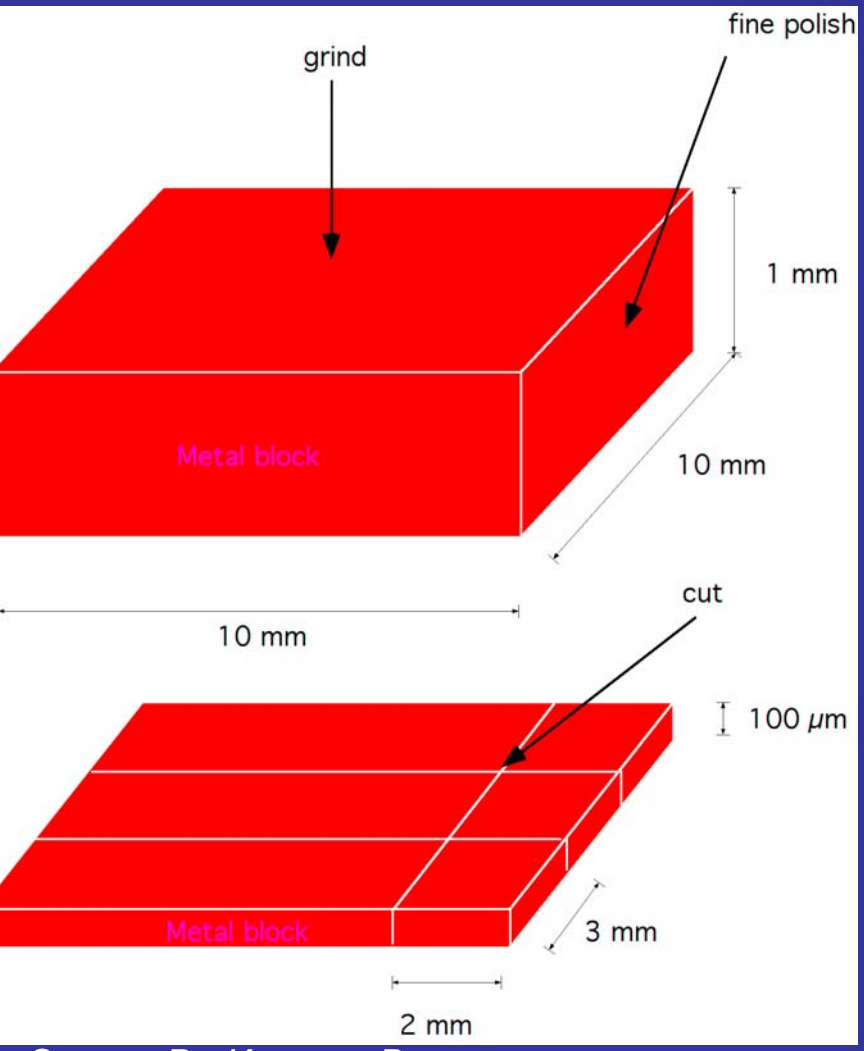
A – cutting a bulk monocrystal (e.g. Co), black side is finely polished

B - polishing on tripod

C - mounting on metal ring

D - cutting a window with focused ion beam (FIB)

2. Specimen preparation by FIB



Desired advantages:

- monocrystal specimen
- electron transparent
- flat specimen surface
- large enough even for XMCD

Possible disadvantages:

- modification of the crystal surface
- thickness not exactly predetermined
- expensive technique

Adequate monocrystals have already been cut and polished in Regensburg and have been sent to Bremen.

-> first feedback right ahead!

3. Switching of objective lens current on Tecnai microscopes

Dichroic effect should be reversed by inverted magnetisation ->

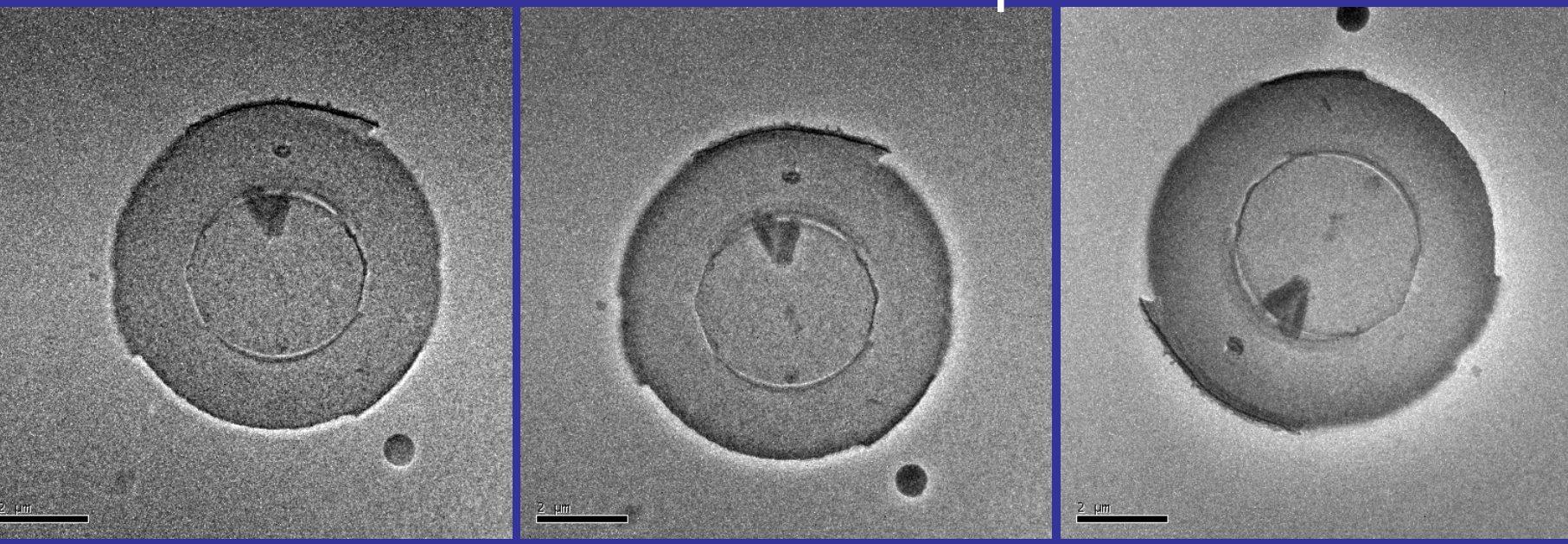
so commutate the objective lens !!

First try on CM30 with Lorentz lens:

- Replacing the objective lens power supply with external power supply

- reversal of the external power supply easily possible…

3. Switching of objective lens current on Tecnai microscopes



Permalloy dot (diameter about 8µm):

left: SA3900x standard imaging mode,

middle: external power supply on objective lens at 11.49A,

right: external power supply at –11.49A, C2 lens manually adjusted

First results on the CM30 -> nessessity of improvements

3. Switching of objective lens current on Tecnai microscopes

Next approach: **TECNAI F30**
Commutation of the objective lens right after the (origin) power supply

vicious circle: TEM measures voltage at OL

-> commutation -> voltage at OL to low -> raise voltage

-> (measured) voltage gets lower -> raise voltage ->

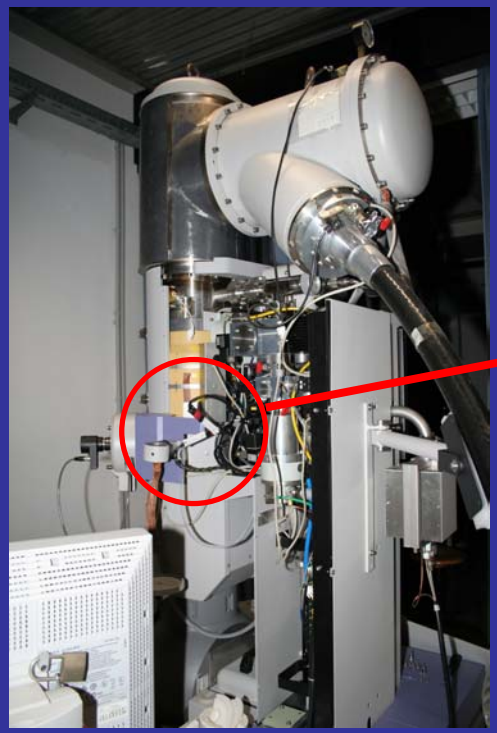
3. Switching of objective lens current on Tecnai microscopes

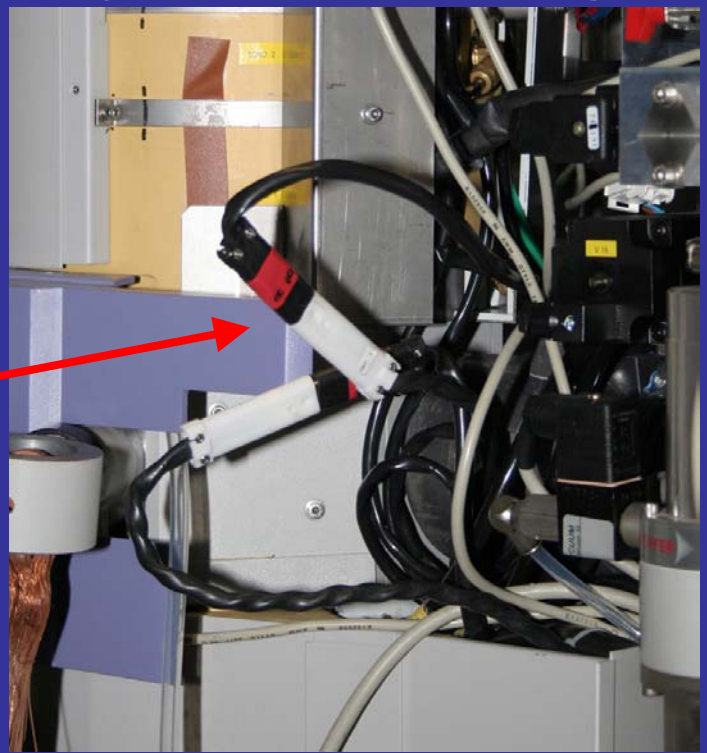
Next approach: **TECNAI F30**

~~Commutation of the objective lens right after the (origin) power supply~~

Better solution:

Commutation of both objective lens coils right at the coils!



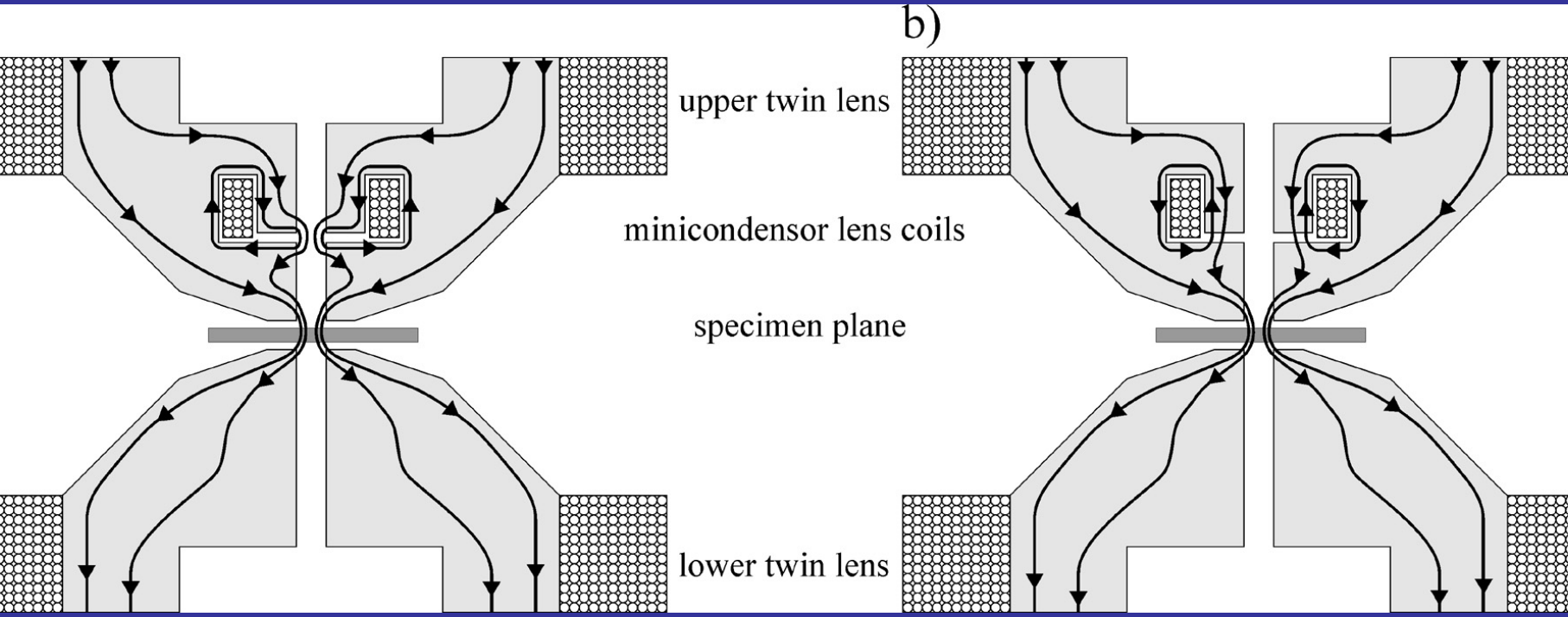


Installation of an adapter for manual commutation

objective lens has to be deactivated while switching !!!

3. Switching of objective lens current on Tecnai microscopes

Problem: Reversing OL current deactivates function of the minicondensor lens (C3)!
-> this is equivalent to switching from microprobe to nanoprobe



a) OL system in microprobe mode

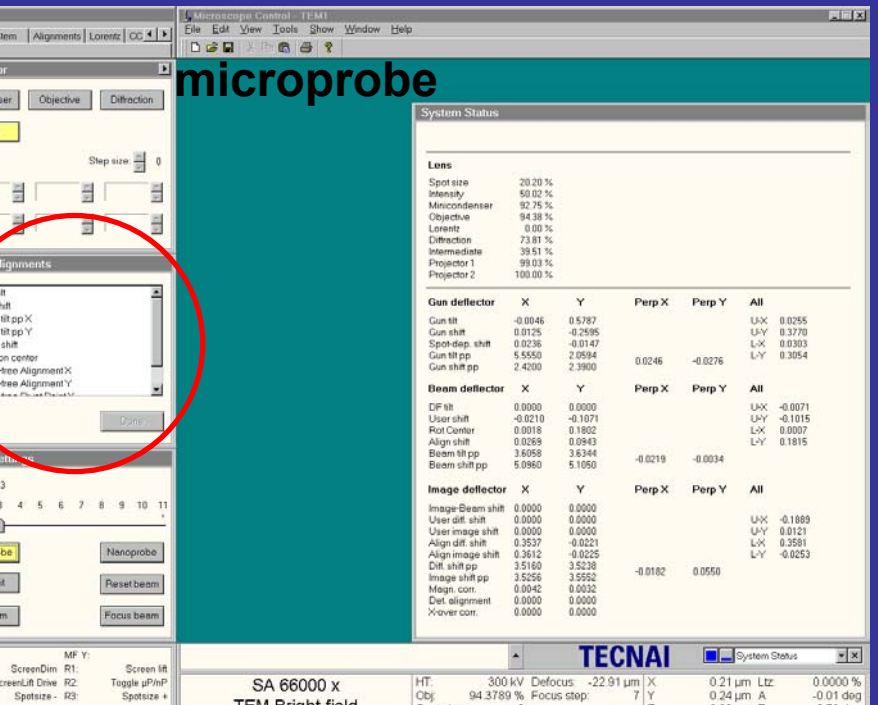
b) OL system in nanoprobe mode

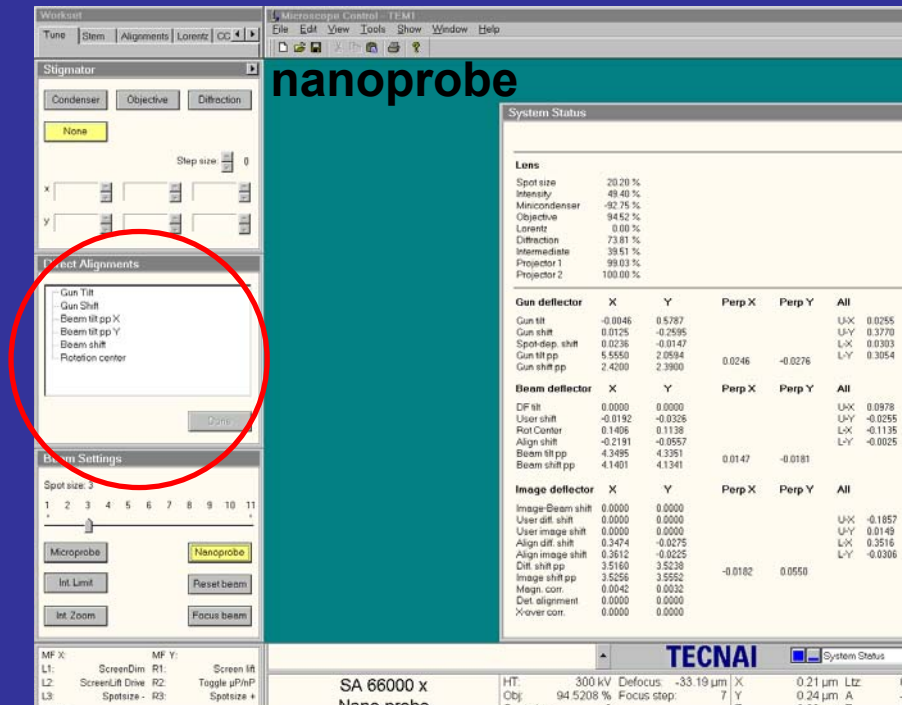
3. Switching of objective lens current on Tecnai microscopes

Problem: Reversing OL current deactivates function of the minicondensor lens (C3)!
-> equivalent switching from microprobe to nanoprobe

Possibility: switching to nanoprobe after commutation -> „normal“ TEM-image again

But: different alignment in nanoprobe mode, not all steps for alignment availabl





3. Switching of objective lens current on Tecnai microscopes

Problem: Reversing OL current deactivates function of the minicondensor lens (C3)!
-> equivalent switching from microprobe to nanoprobe

~~Possibility: switching to nanoprobe after commutation -> „normal“ TEM-image~~

Best solution: concurrent commutation of the objective lens and the minicondensor lens (C3)!

3. Switching of objective lens current on Tecnai microscopes

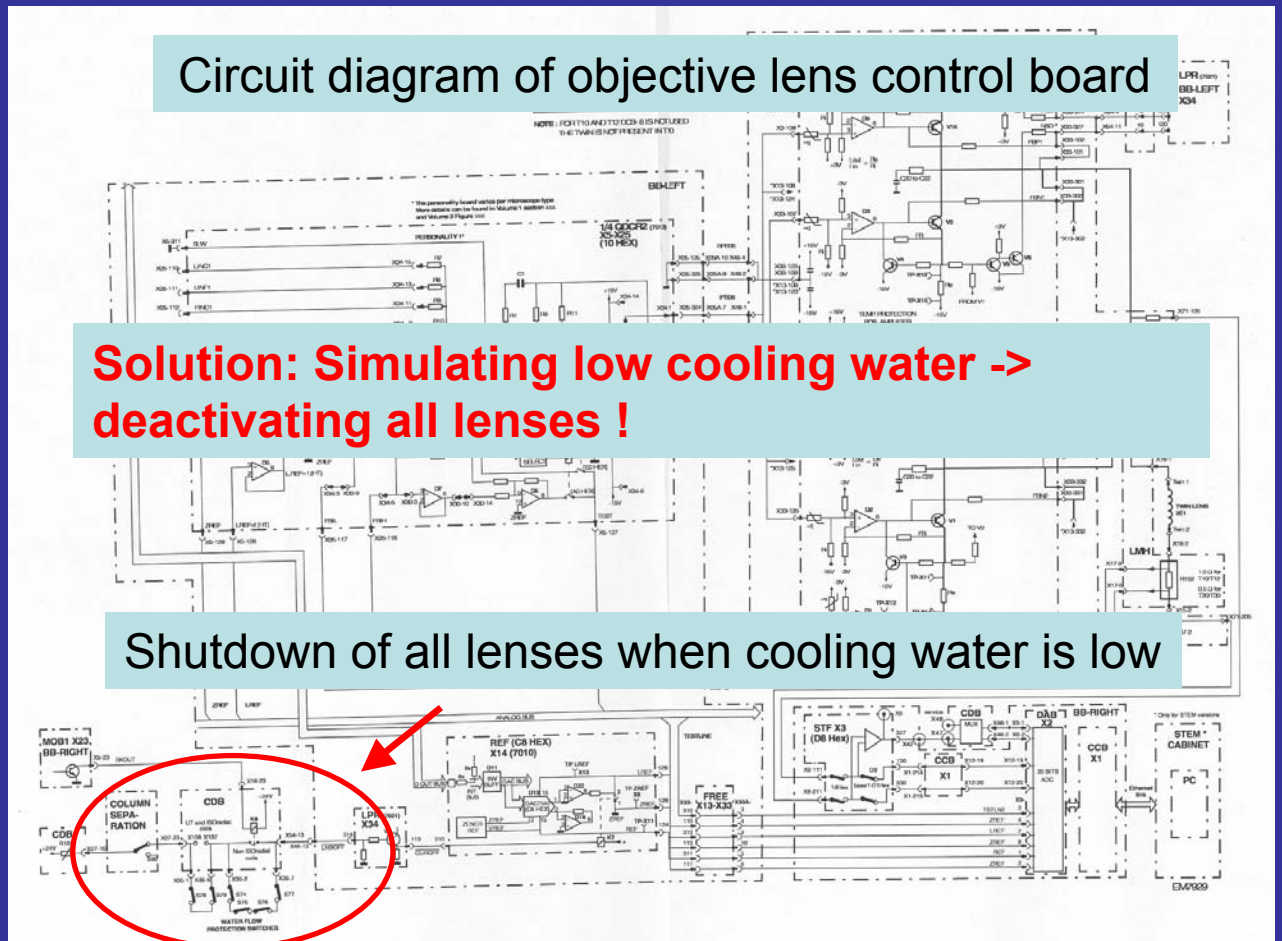
Best solution: commutation also of the minicondensor lens (C3)!

Problem: minicondensor lens coil have no connectors at the colum…

… found it on the dual distribution board in the TEM cabinet!

3. Switching of objective lens current on Tecnai microscopes

Problem: all lenses must be deactivated when commutating
(using Lorentz-mode in Regensburg, not available in Vienna!)

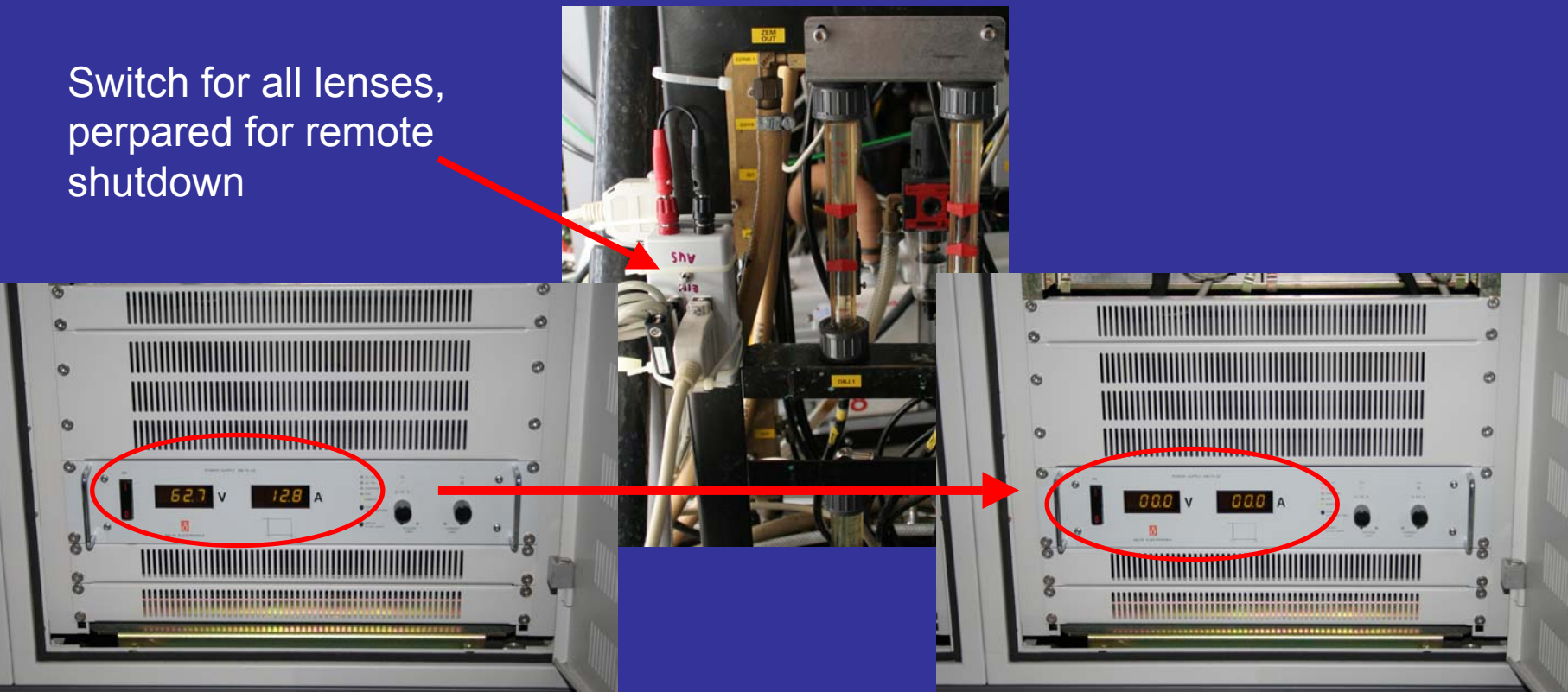


3. Switching of objective lens current on Tecnai microscopes

Problem: all lenses must be deactivated when commutation
(using Lorentz-mode in Regensburg, not available in Vienna!)

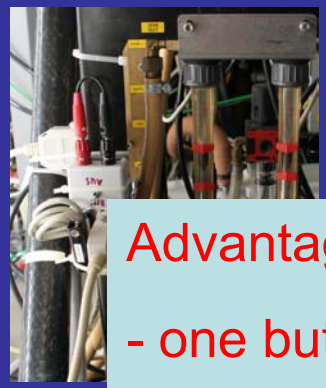
Solution: Simulating low cooling water -> deactivating all lenses !

Switch for all lenses, perpared for remote shutdown

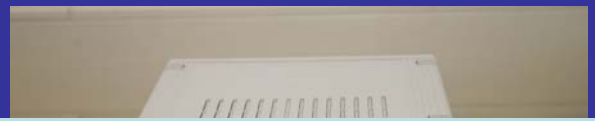


3. Switching of objective lens current on Tecnai microscopes

Automatic unit for commutation of objective lens and minicondensor lens (prototype):

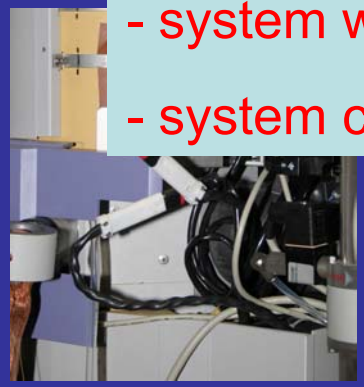


1. All le ens



Advantages:

- one button for complete commutation cycle
- maloperation not possible
- system will be installed in a few hours (no wires to be cut!)
- system can be uninstalled in half an hour



2. Reversing obj. lens

4. All lenses on again

3. Switching of objective lens current on Tecnai microscopes

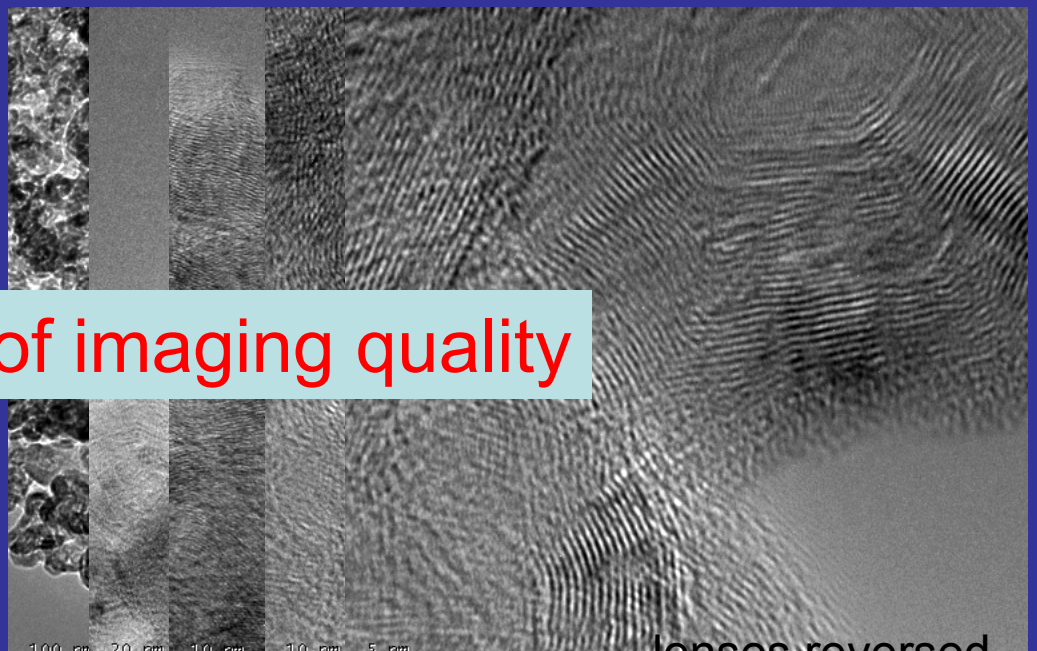
What about the image quality with commutated lenses?

3. Switching of objective lens current on Tecnai microscopes

Performance of the Tecnai microscope after commutation

-> Need for a separate alignment, focus, illumination, eucentric height, specimen area has to be adjusted manually

Example for high resolution: graphit particles (fringe distance 0,34nm)



No deterioration of imaging quality

normal“ mode

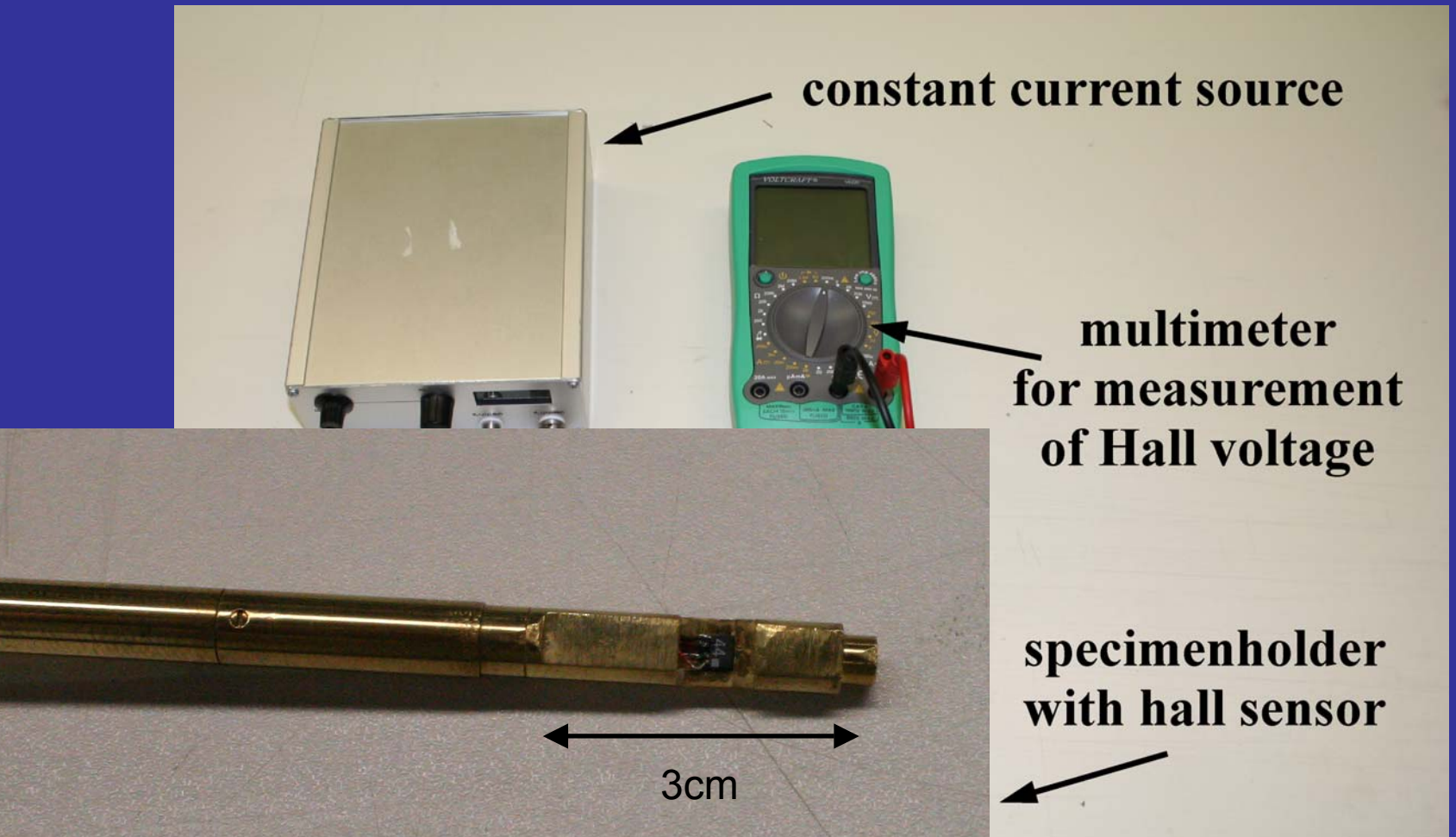
lenses reversed

3. Switching of objective lens current on Tecnai microscopes

Is there any change after a commutation cycle?

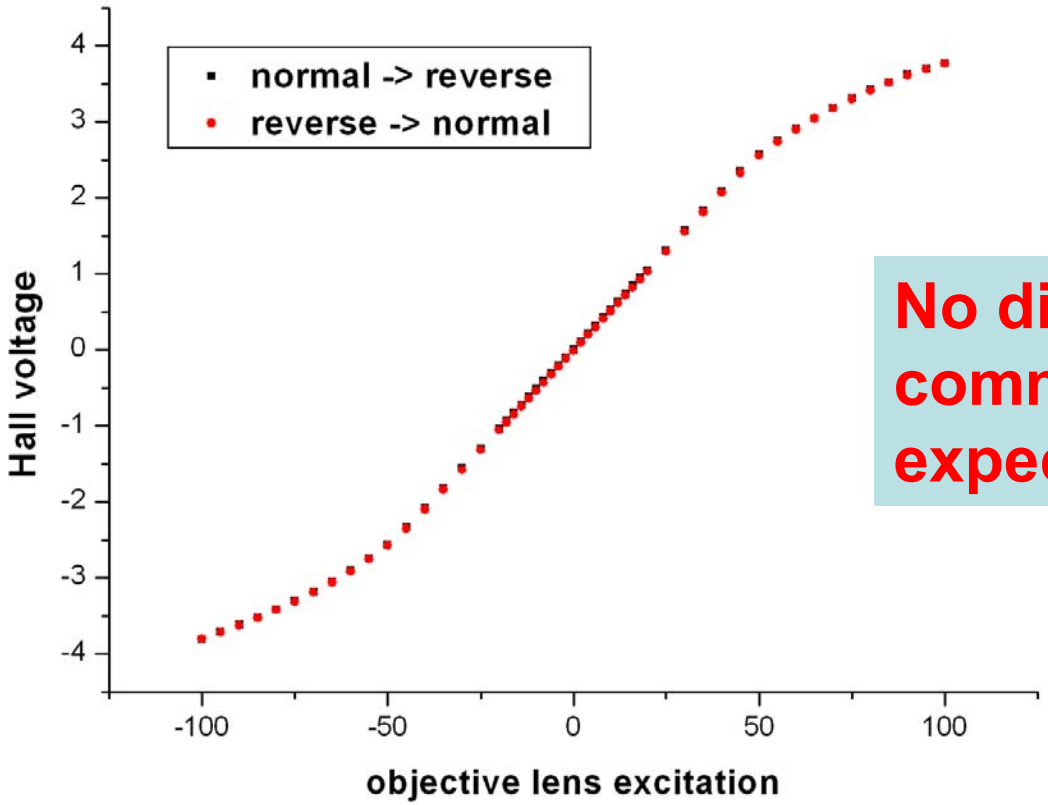
3. Switching of objective lens current on Tecnai microscopes

Measurement of the magnetic field in the specimen plane during the commutation cycle (object. lens AND C3 lens):



3. Switching of objective lens current on Tecnai microscopes

Measurement of the magnetic field in the specimen plane during the commutation cycle (object. lens AND C3 lens):

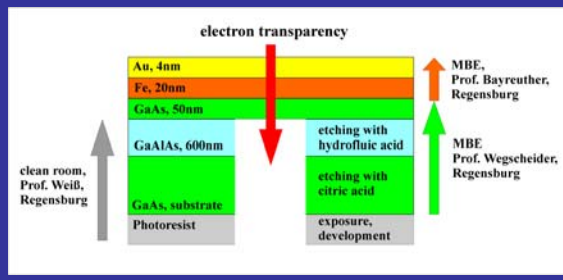


No hysteresis detectable

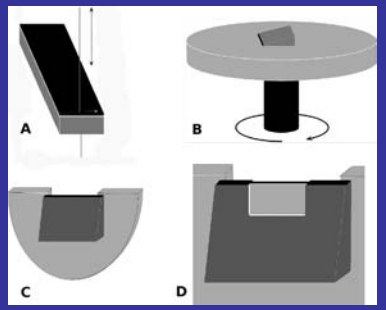
No disadvantages after commutation cycle expected!

4. Summary / Prospect

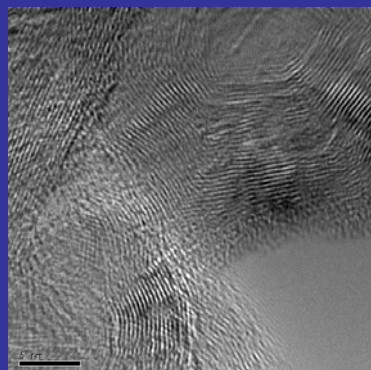
- Fe on GaAs probably not useful for CHIRALTEM…



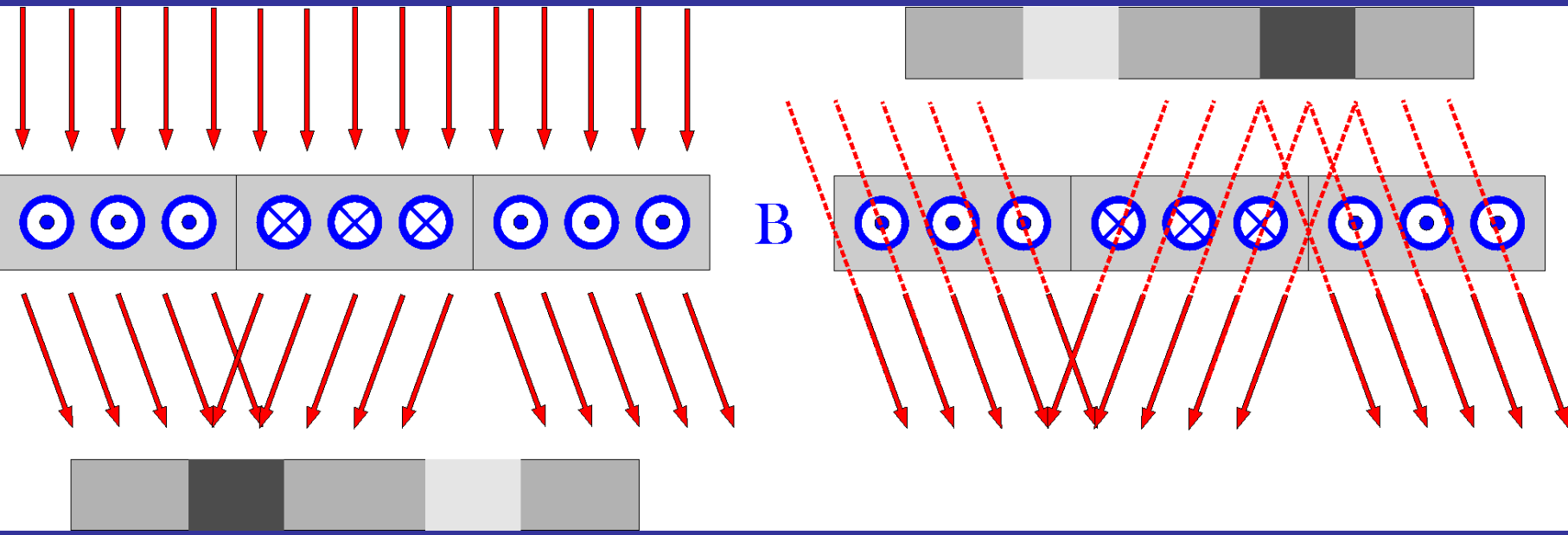
- First CHIRALTEM specimen produced by FIB is just beeing prepared



- Objective lens switching procedure is working, switching unit will be available upon delivery of the connectors by FEI



Function of lorentz microscopy



Fresnel imaging in overfocus… **… and in underfocus**