WP 6 Task 6.1 SQUID scanning

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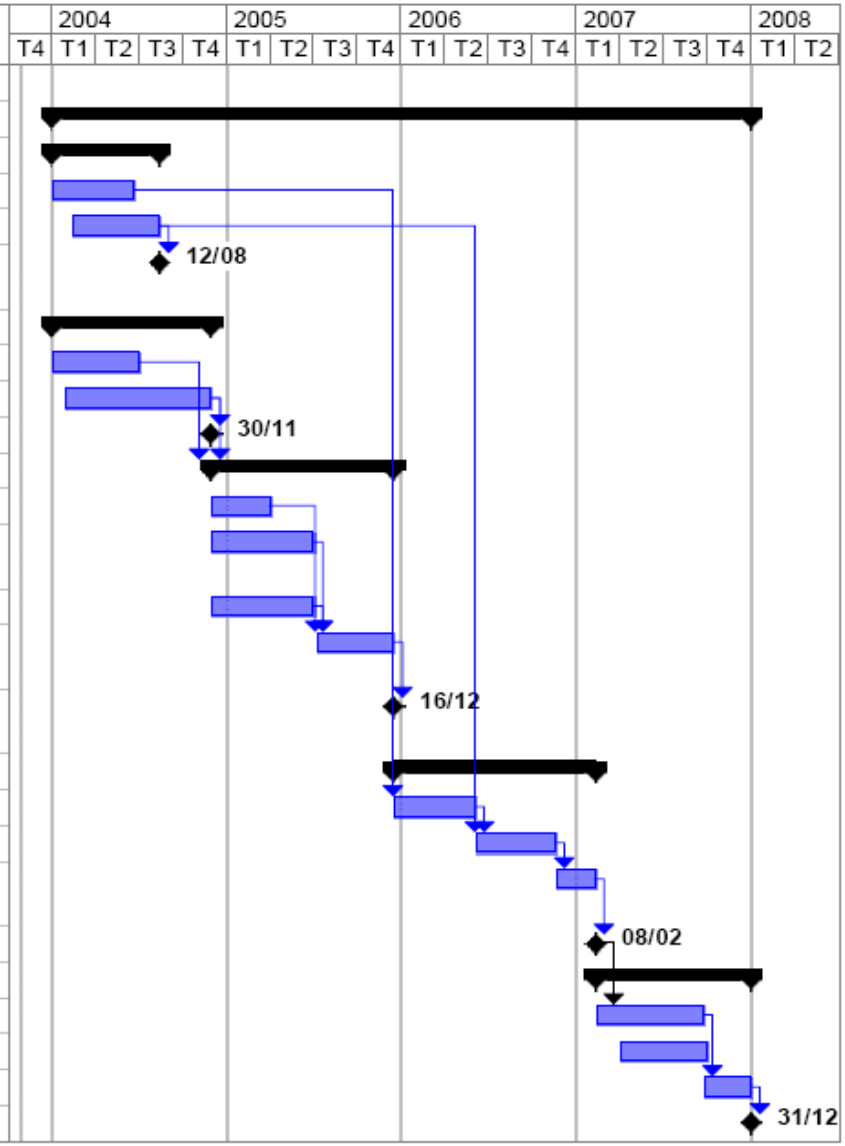
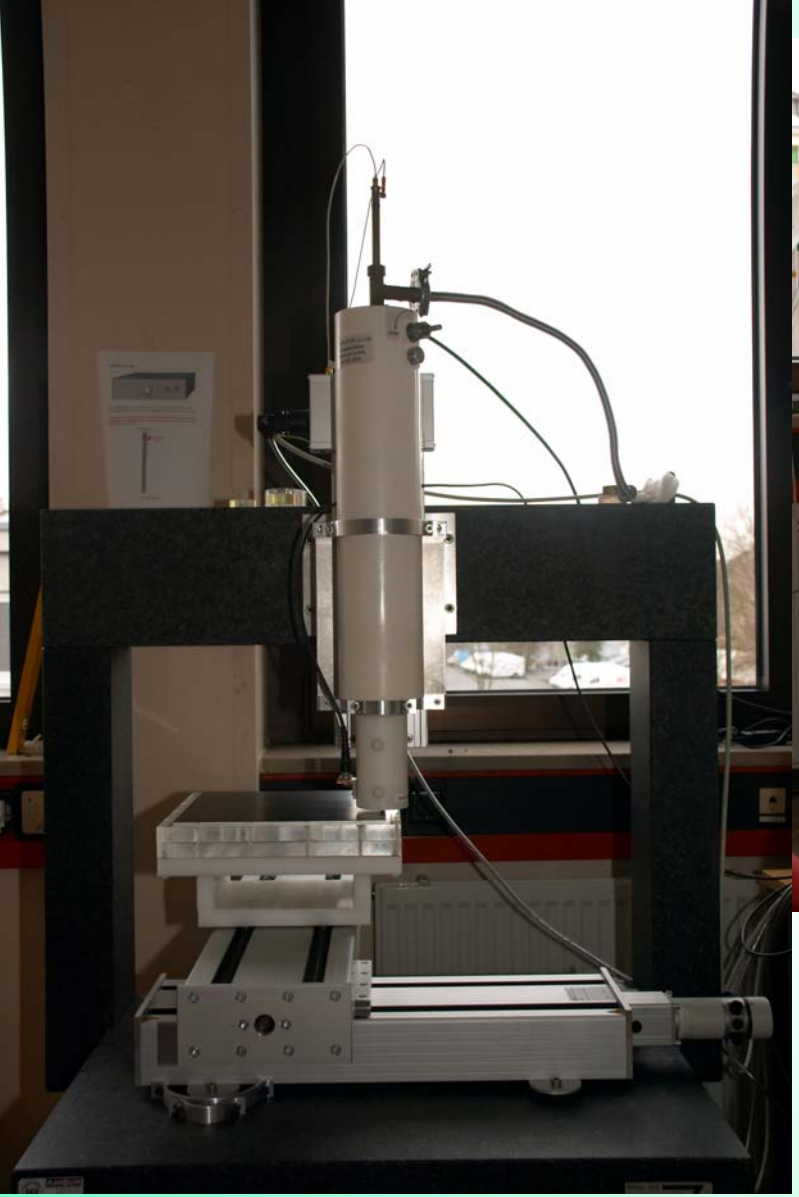
Task Name	Milestones, Deliverables
WP6 MATERIAL ANALYSIS	
Squid scanning	
Produce calibration defects	
Production of surface defects	
Production of bulk defects	
MS Calibration defects finished	**Report, Calibration defects ready**
Design components of Squid scanner	
Design of the scanning table and support	
Design of the SQUID cooling system	
MS Design Scanner finished	**Design Report**
Construction of scanning apparatus	
Fabrication of the SQUID	
Fabrication and purchase of components for SQUID apparatus	
Software for the SQUID scanner	
Commissioning and calibration of scanning apparatus	
MS Scanning apparatus operational	**Scanning apparatus ready**
Scanning of sheets with artificial defects	
Scanning of sheets with artificial surface defects	
Scanning of sheets with artificial bulk defects	
Development of algorithm for material defects classification	
MS Classification of defects finished	**Intermediate Report**
Scanning of production sheets	
Scanning of sheets of different producers	
Identification of defects by (EDX, SURFA etc.)	
Conclusive comparison with eddy current data	
MS Final report on Squid scanning	**Final Report**

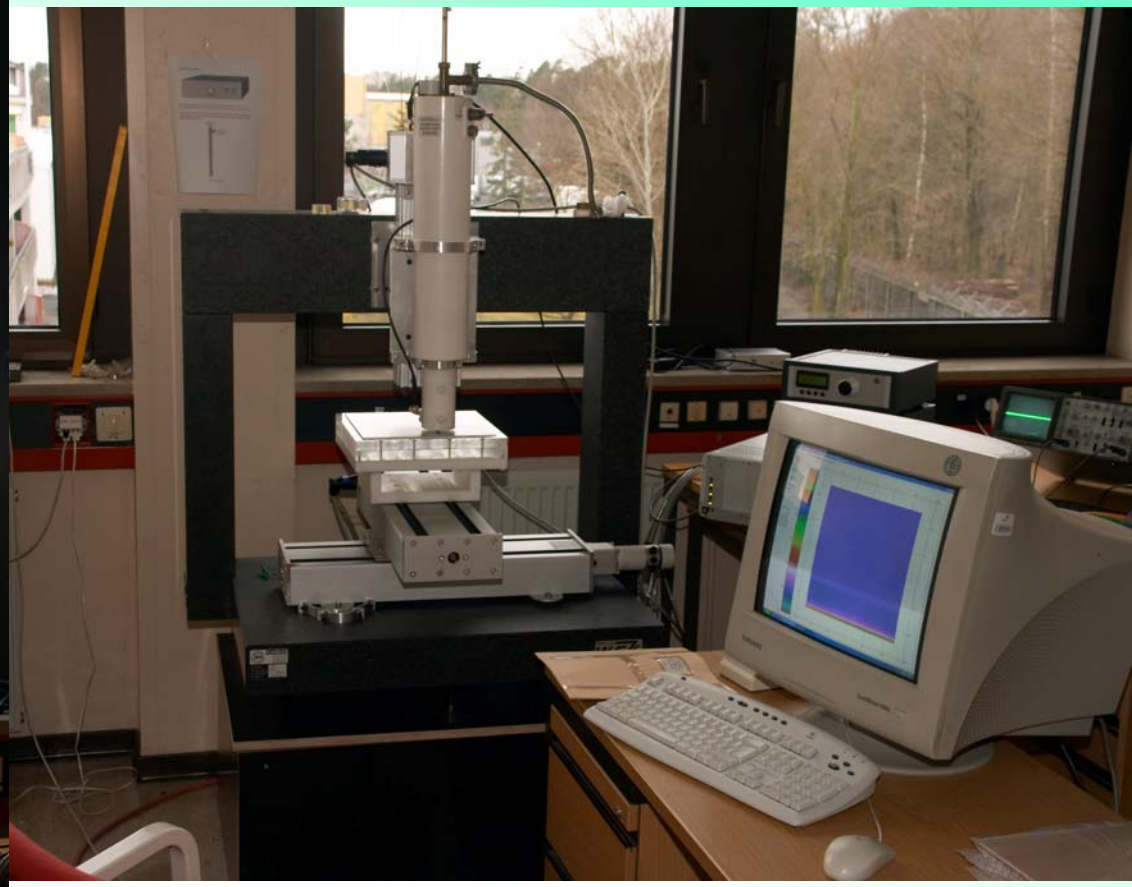


Task: Creating in cooperation with WSK a SQUID scanning system for Nb sheets of 265x265 mm (prototype for XFEL)

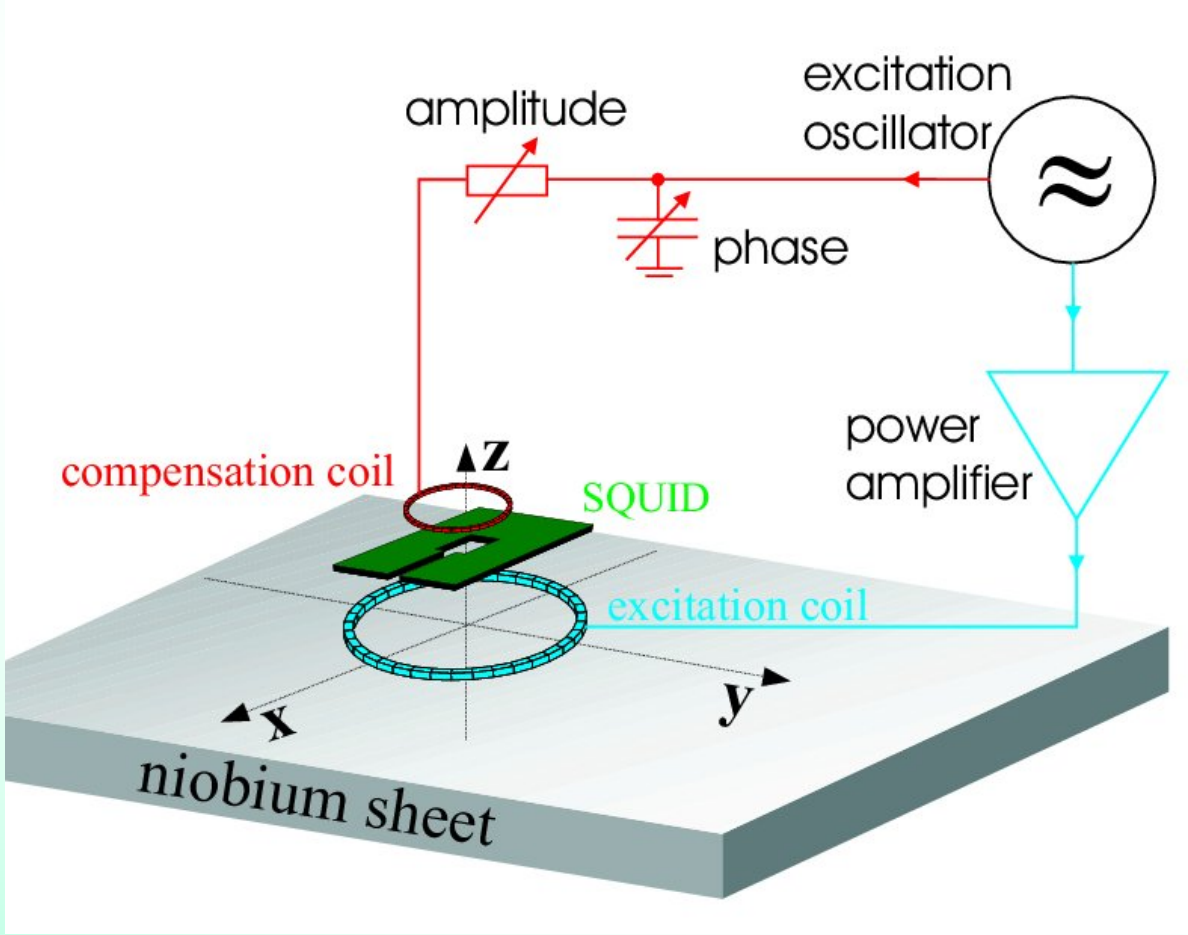
Specification for SQUID scanning system should include:

- XY table (aim rotating table)
- high signal/noise ratio
- compensation of lift off effect
- rather fast scanning (5-10 min/sheet)
- vacuum holder of the sheet, keeping it flat

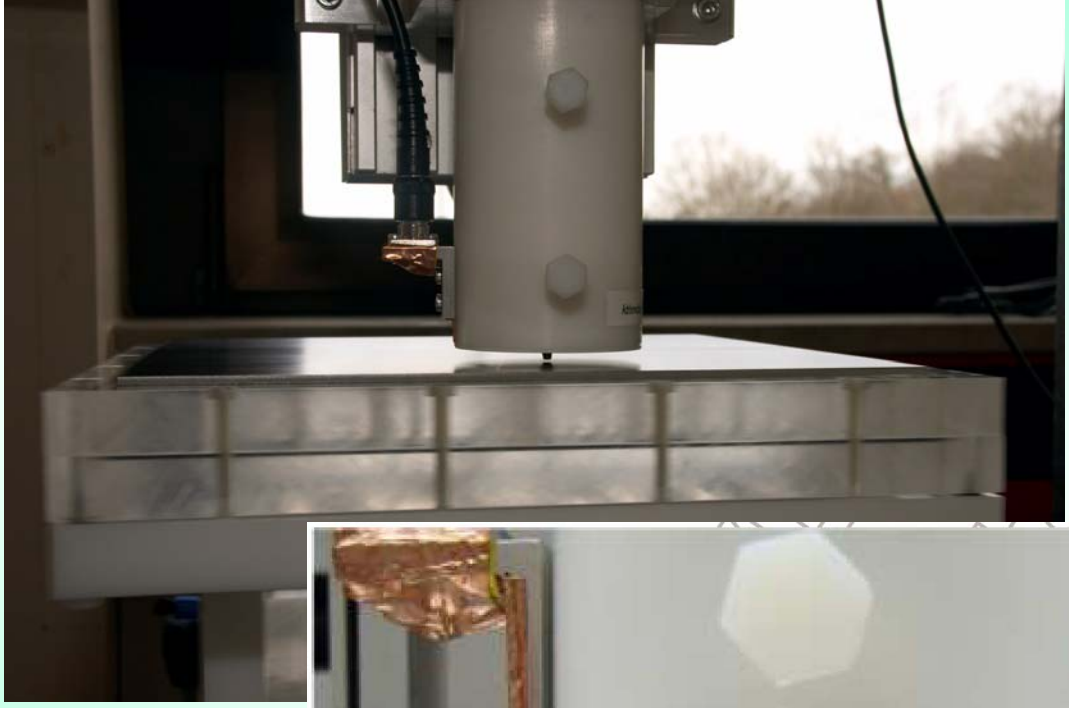


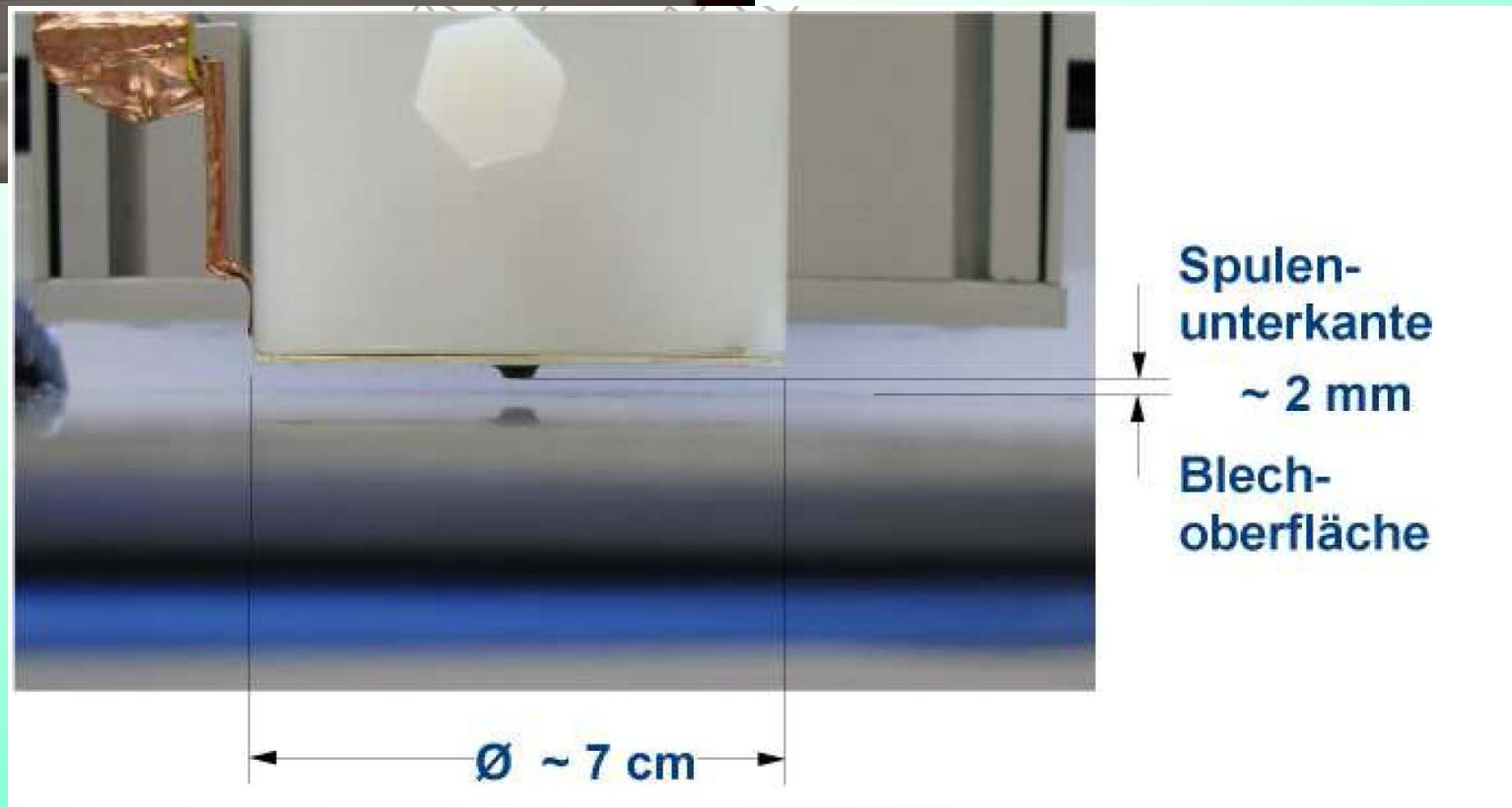


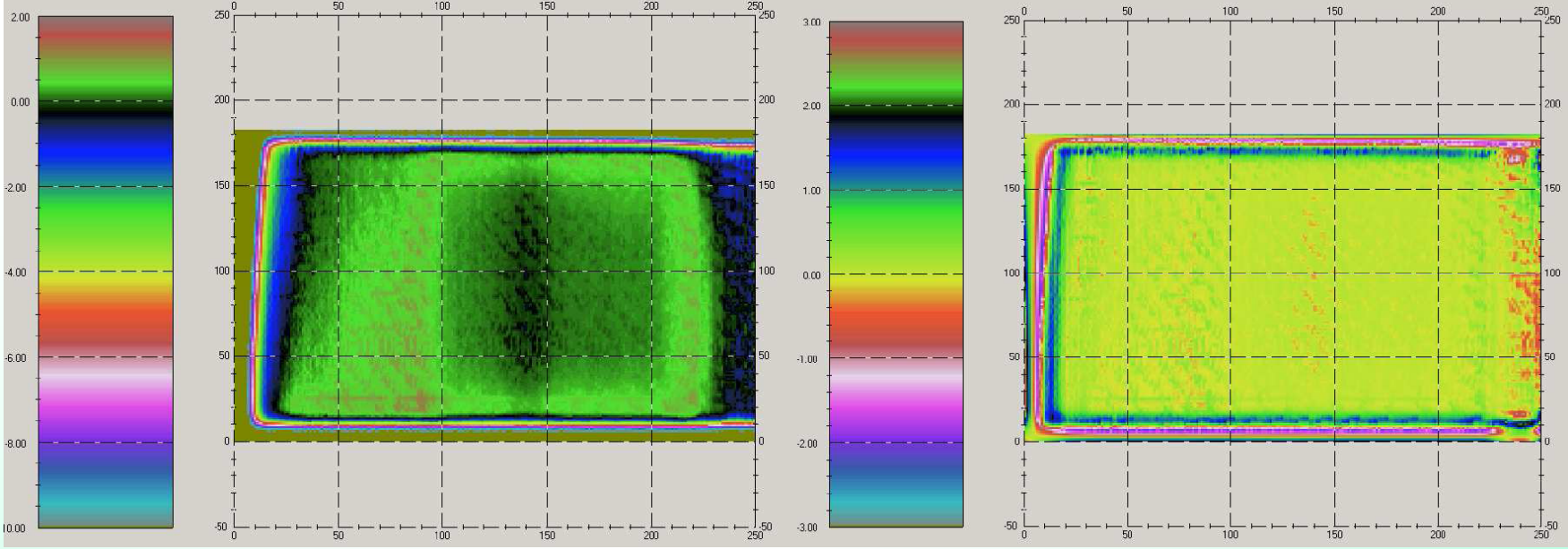
Front view and side view of SQUID scanner



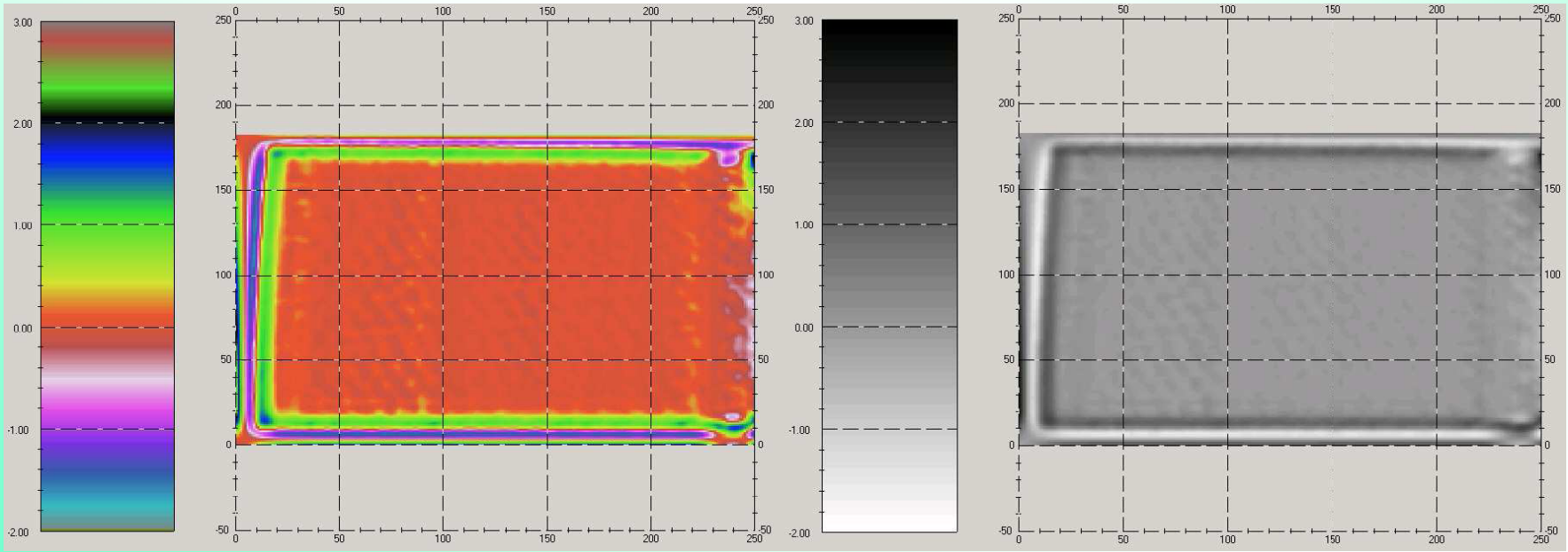
An excitation coil produces eddy currents in the sample, whose magnetic field is detected by the SQUID. A compensation coil close to the SQUID cancels the excitation field at the SQUID.




Spulen-
unterkante
~ 2 mm
Blech-
oberfläche
Ø ~ 7 cm

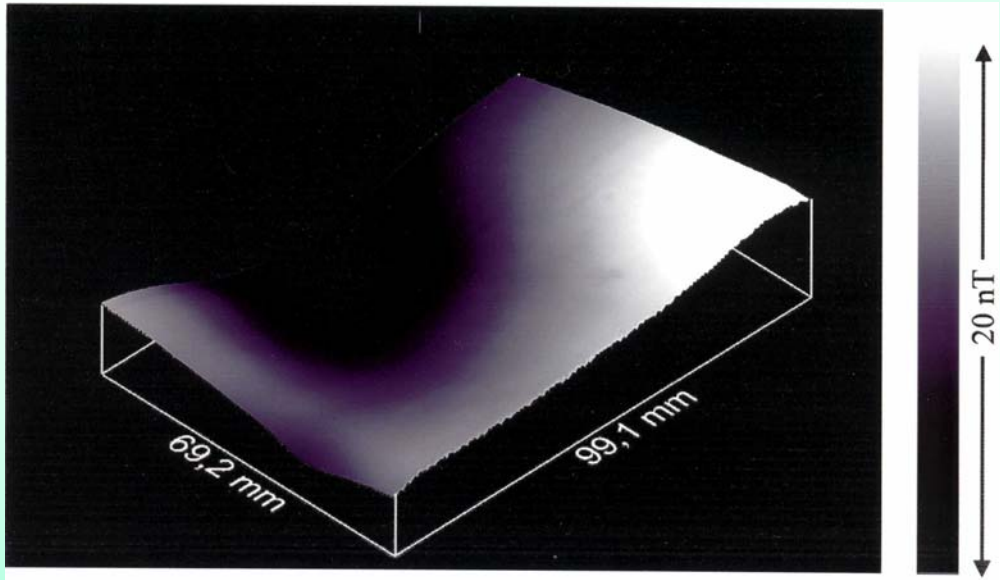


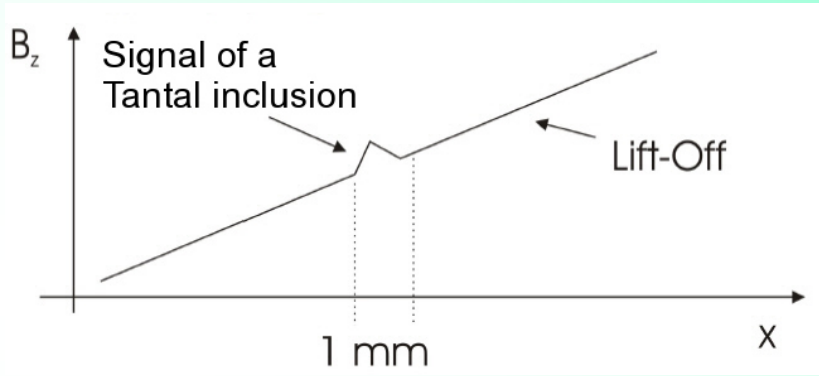
Left: rough data covered by surface topology. Right: after lift off correction

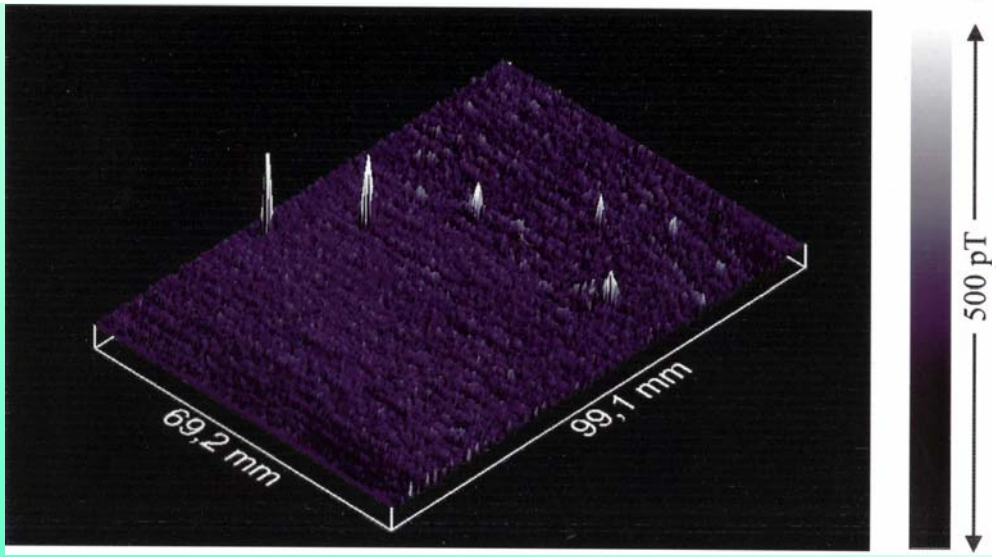


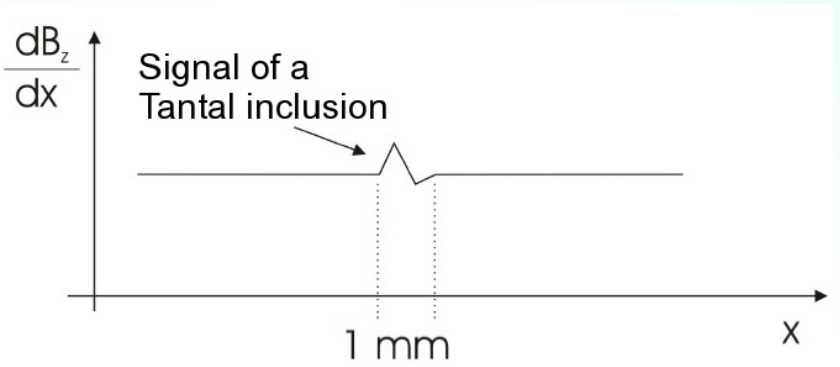
Left: after correction by high pass filter. Right: normalized data for comparison

Lift Off correction of the surface profile of a sheet



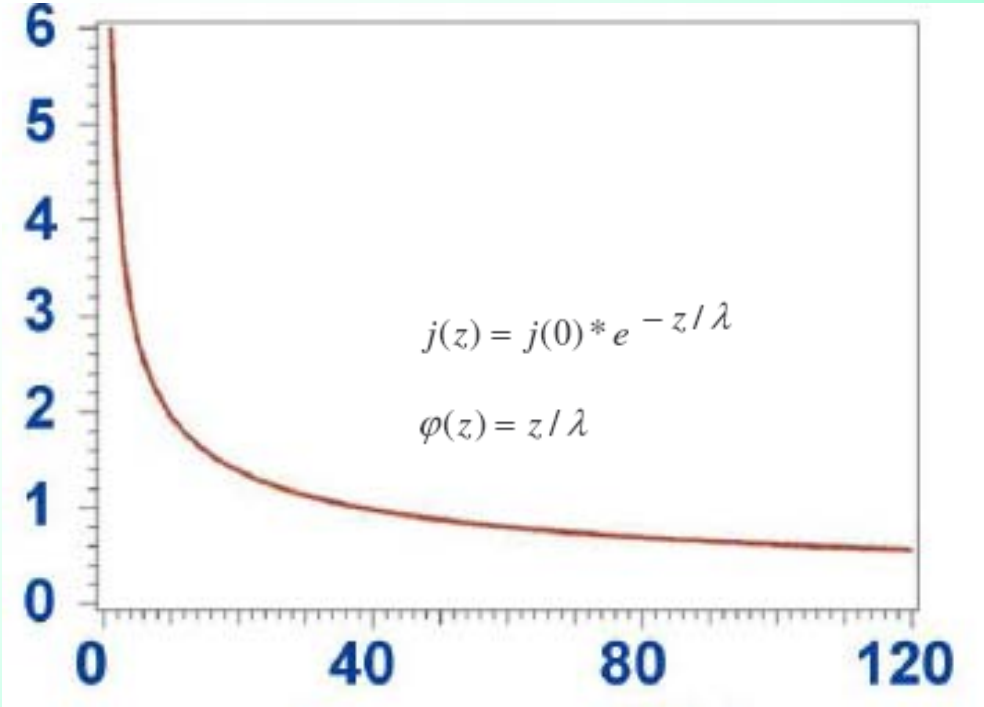






Measurement up to 80 KHz is possible now

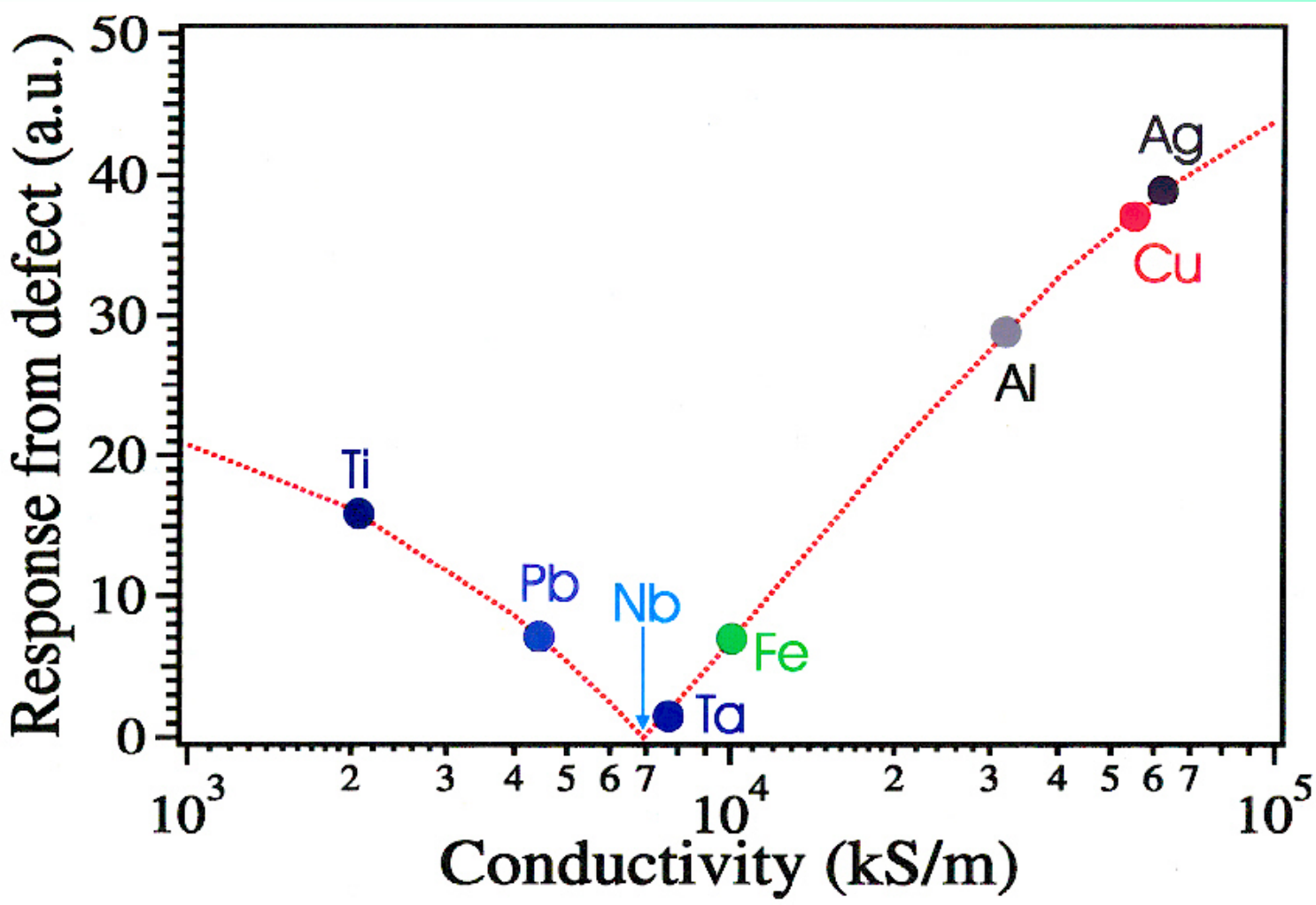
Penetration depth, mm



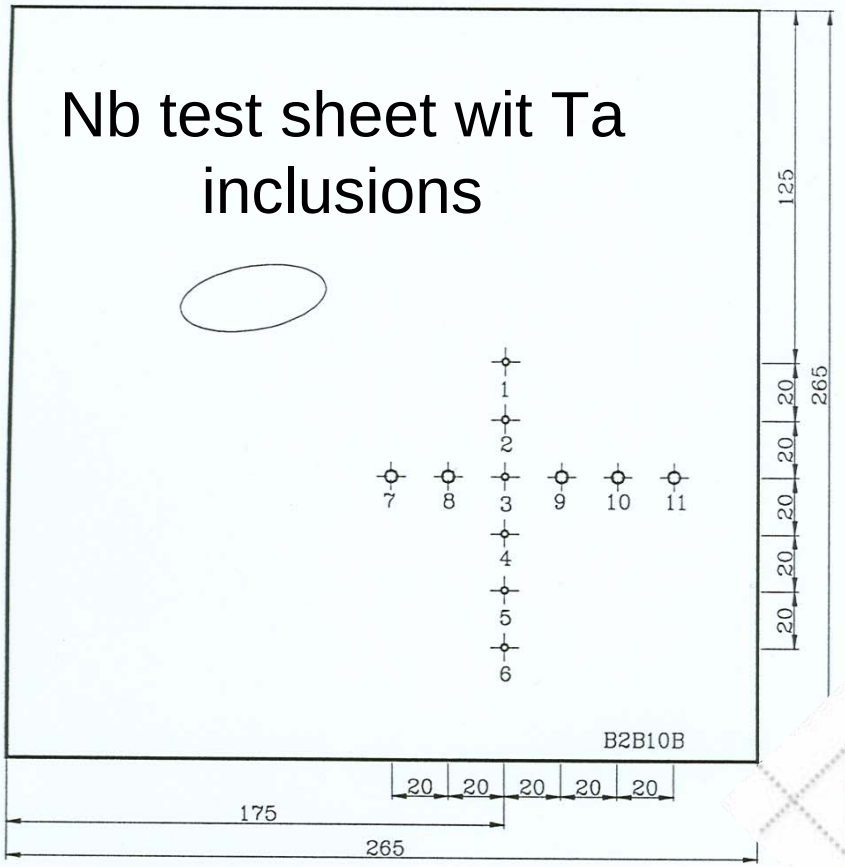
Frequency , kHz

Penetration depth versus frequency

Response from different inclusions in niobium

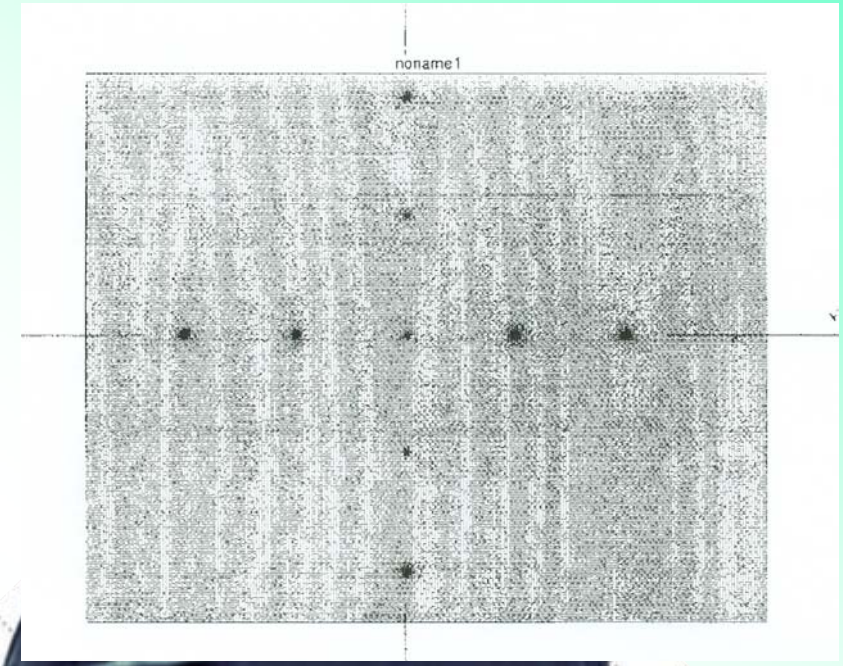


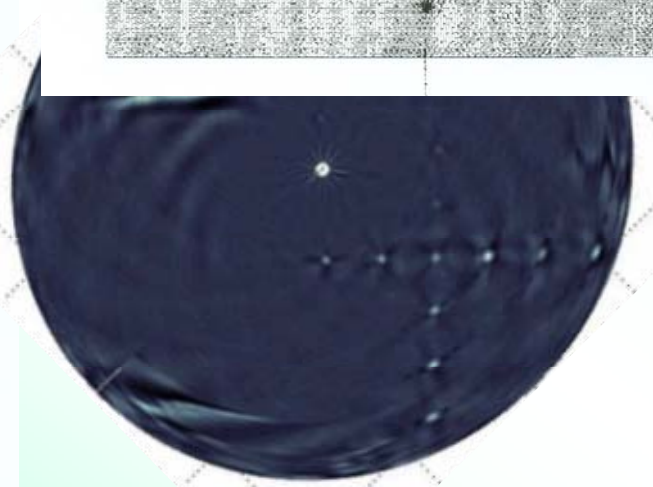
Nb test sheet wit Ta inclusions



Fehler	Sackloch ø[mm]	t[mm]	V[mm³]	mit Tantal gefüllt
1	0,12	0,078	0,0009	Ja
2	0,14	0,21	0,0032	Ja
3	0,145	0,298	0,0049	Ja
4	0,145	0,376	0,0062	Ja
5	0,15	0,474	0,0084	Ja
6	0,15	0,469	0,0083	Nein
7	0,22	0,234	0,0089	Ja
8	0,23	0,333	0,0127	Ja
9	0,22	0,435	0,0165	Ja
10	0,22	0,495	0,0188	Ja
11	0,22	0,501	0,0190	Nein

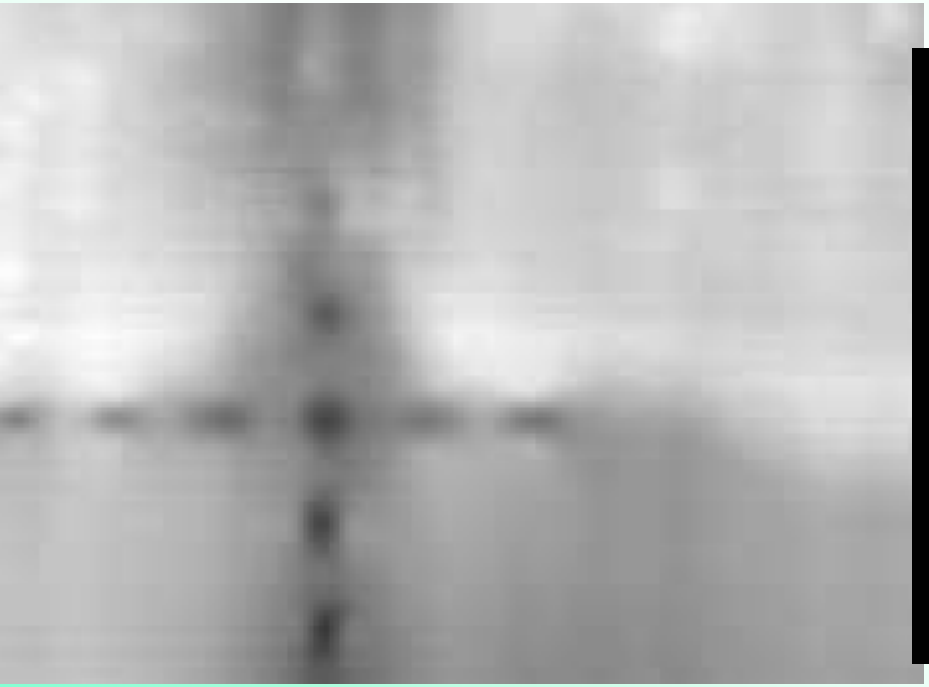
NAA Neutron activation analysis image of the Nb test sheet



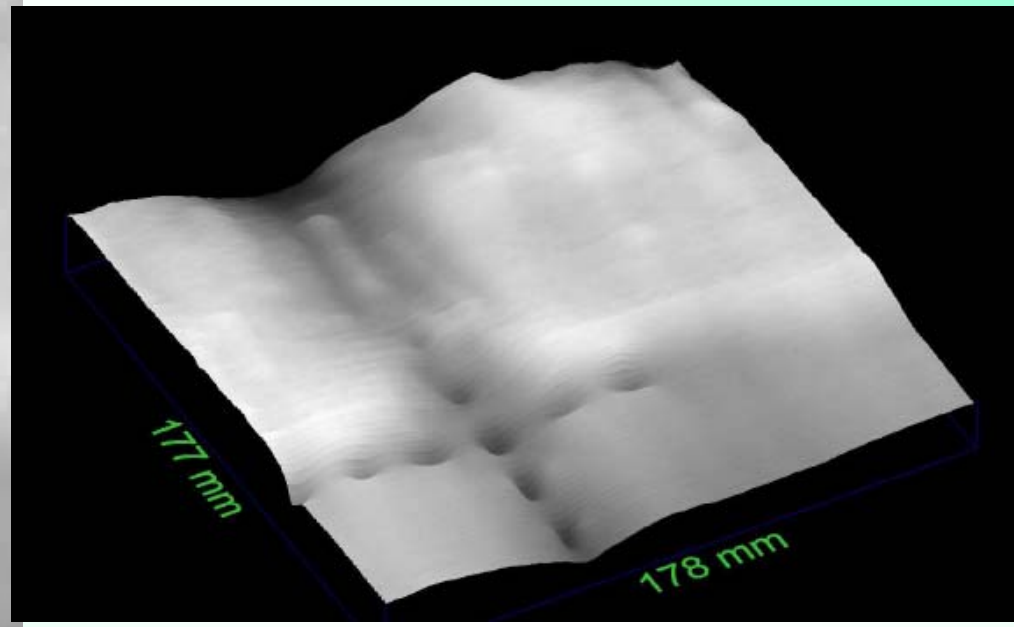


Eddy current image

Nb - test - sheet with Ta - inclusions
SQUID

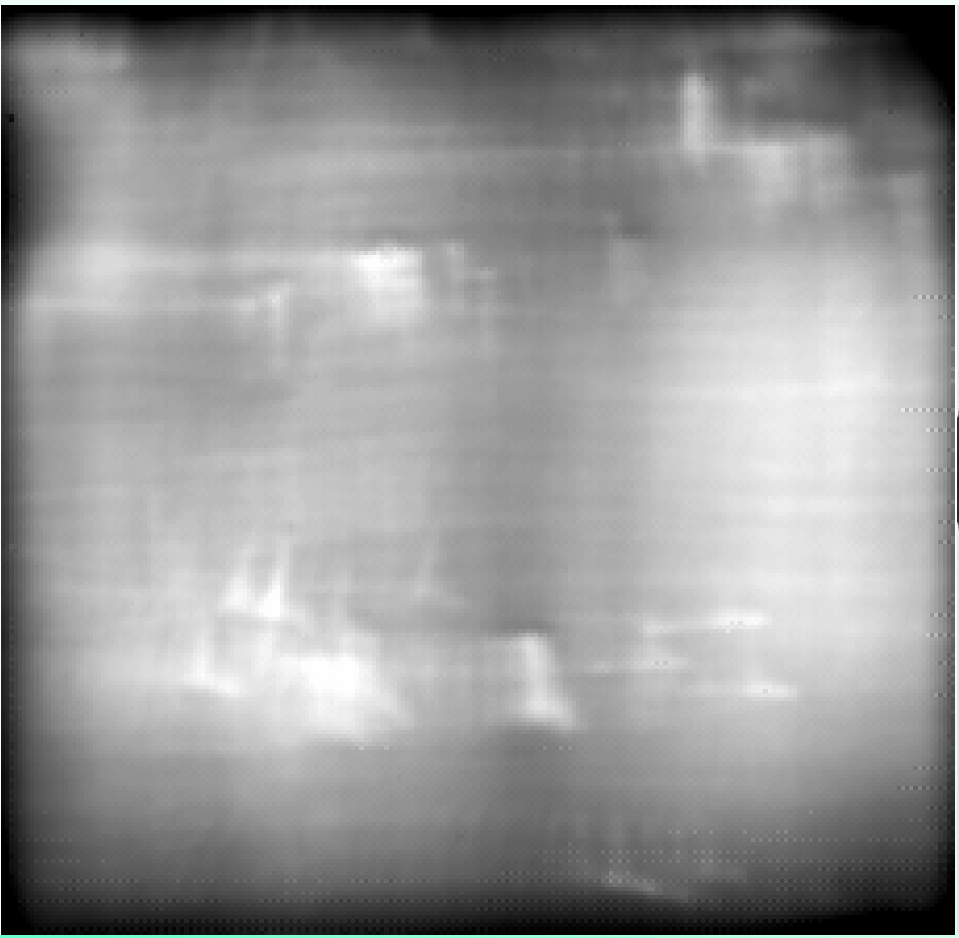


Eddy current with SQUID

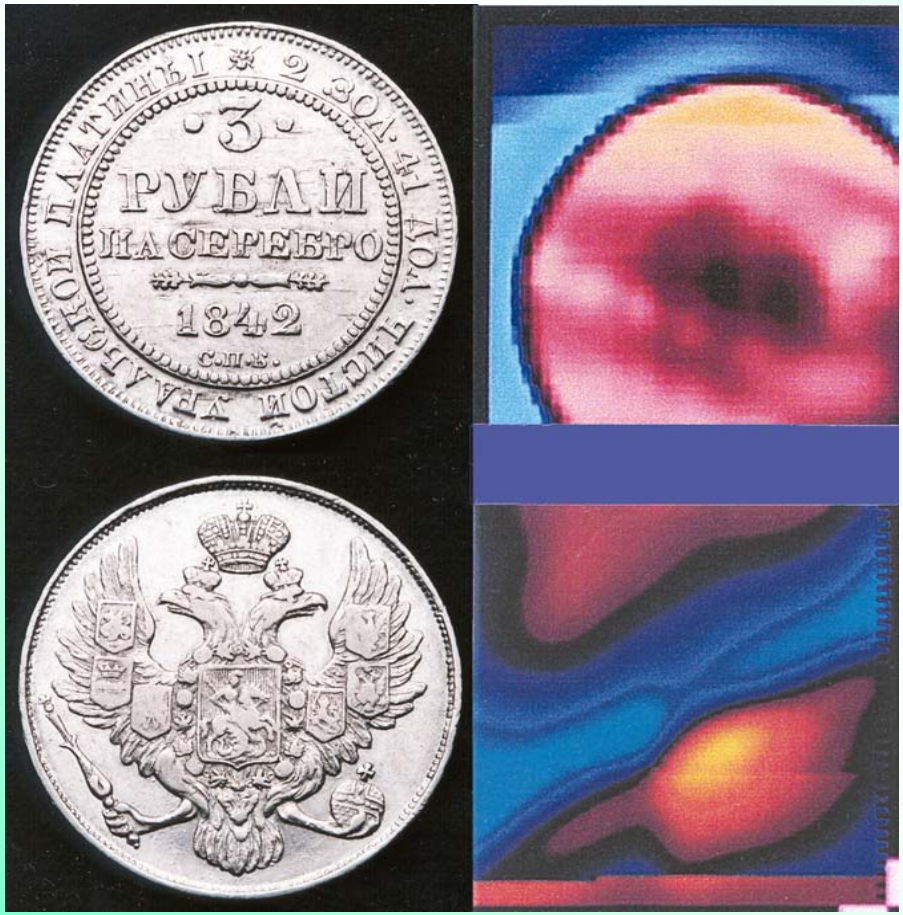


Eddy current without SQUID

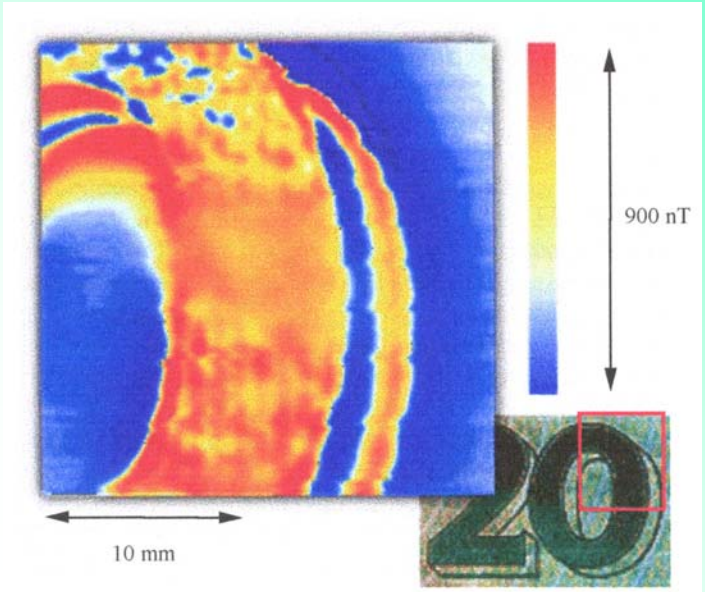
Industrially Nb-sheet comparison measurement
SQUID / Eddy current (No. 45)

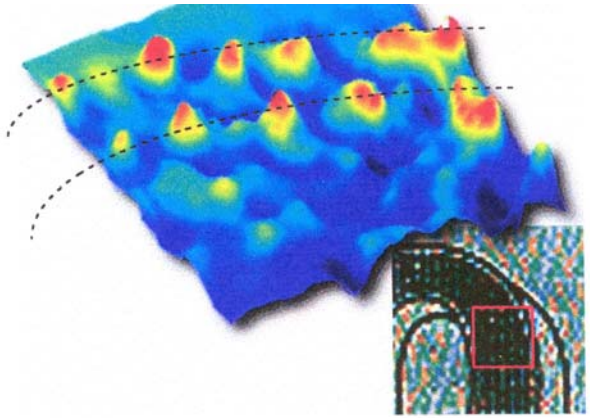


WSK takes care on money



SQUID-test on a russian coin made of raw-platin in powder metallurgy with PtIrFe-phases



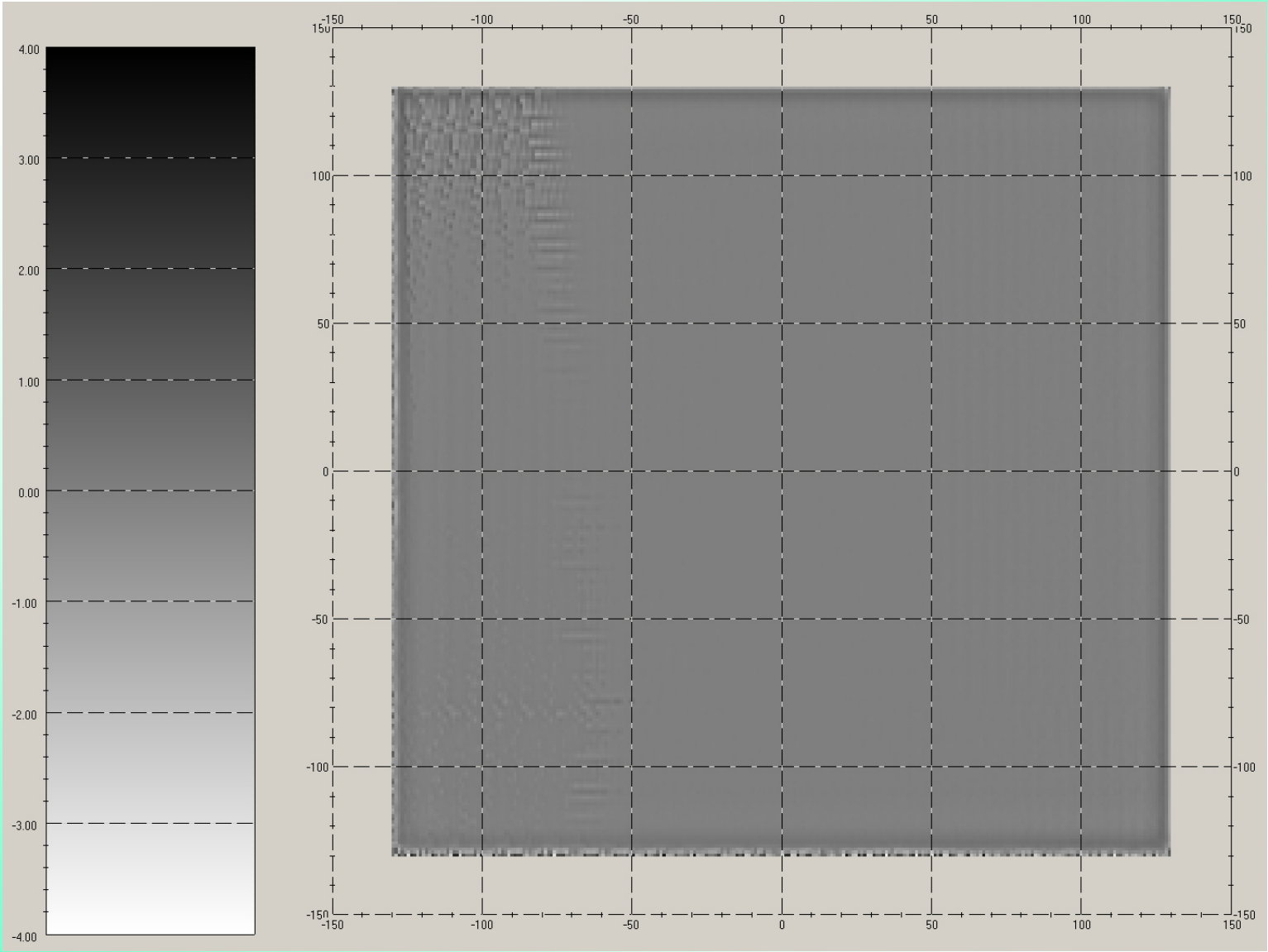


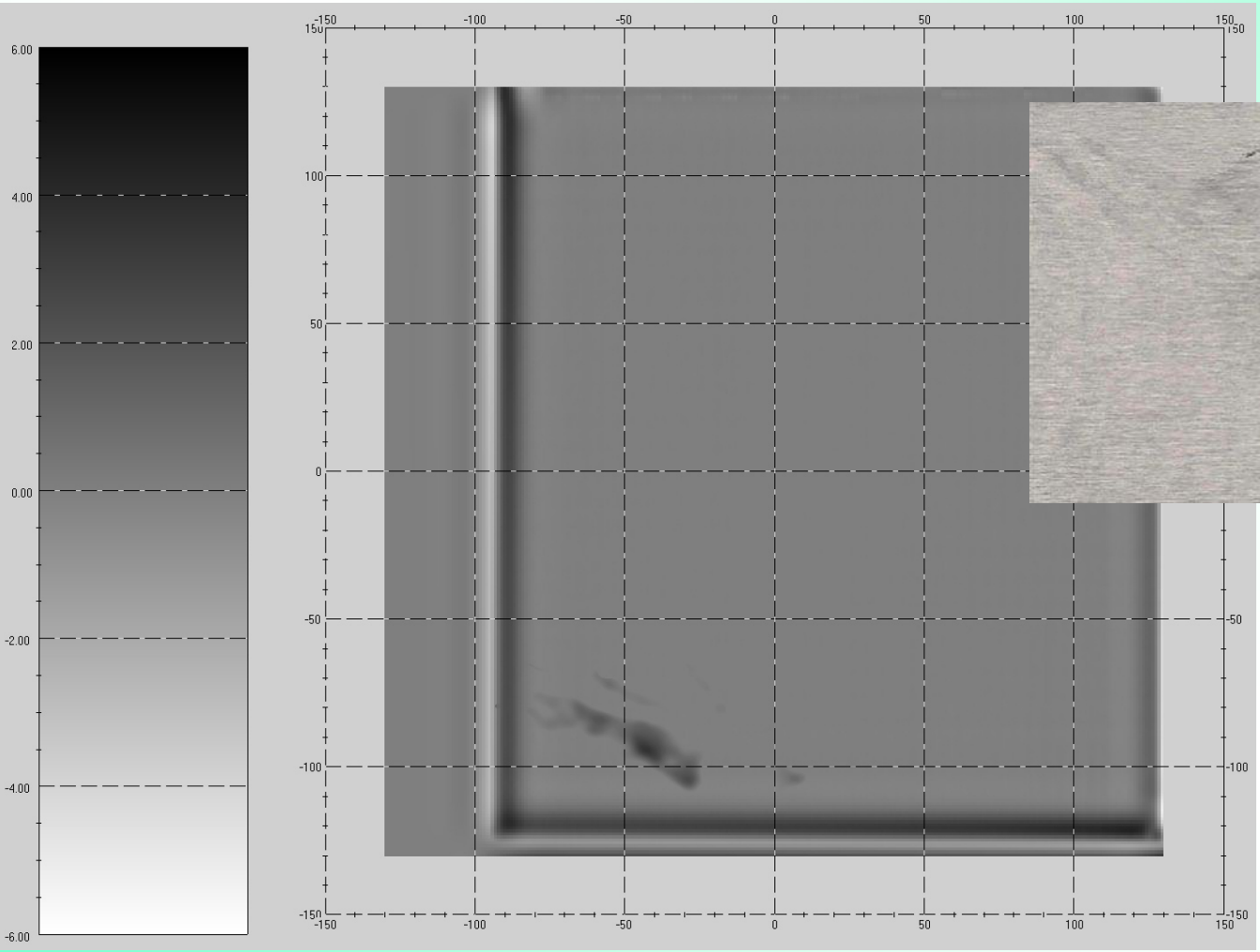
Squid-measurement of print-pixel of a banknote

20 niobium sheets of the Fa. Plansee for the cavity AC115 scanned before annealing with WSK SQUID scanner. Excitation frequency was 6.3 kHz.

- Surface structures (increasing of surface roughness) are detected in some sheets probably caused by the rolling.
- All sheets (excluded sheet No. 28) are defect free.
- The sheet No. 28 has a delomination in the left down corner penetrating from the surface into the bulk.

Sheet No. 14 (surface roughness)



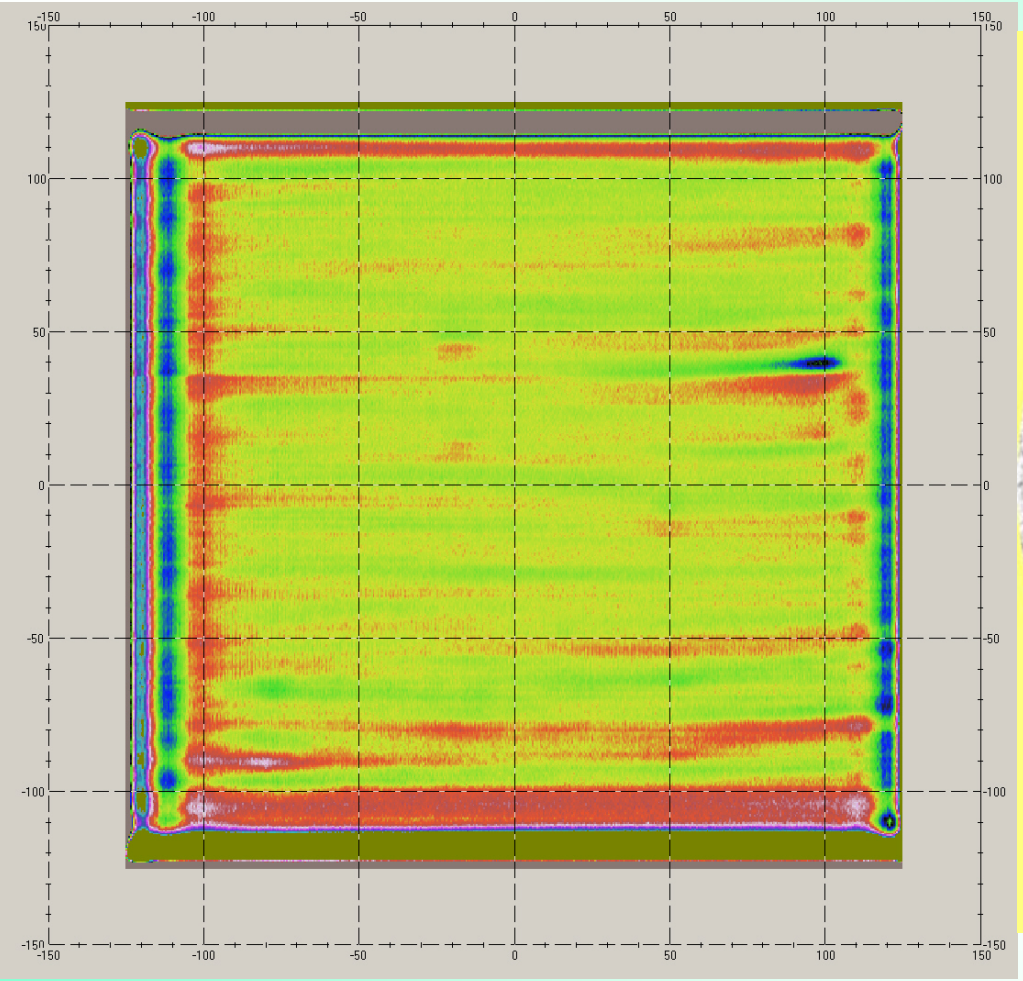


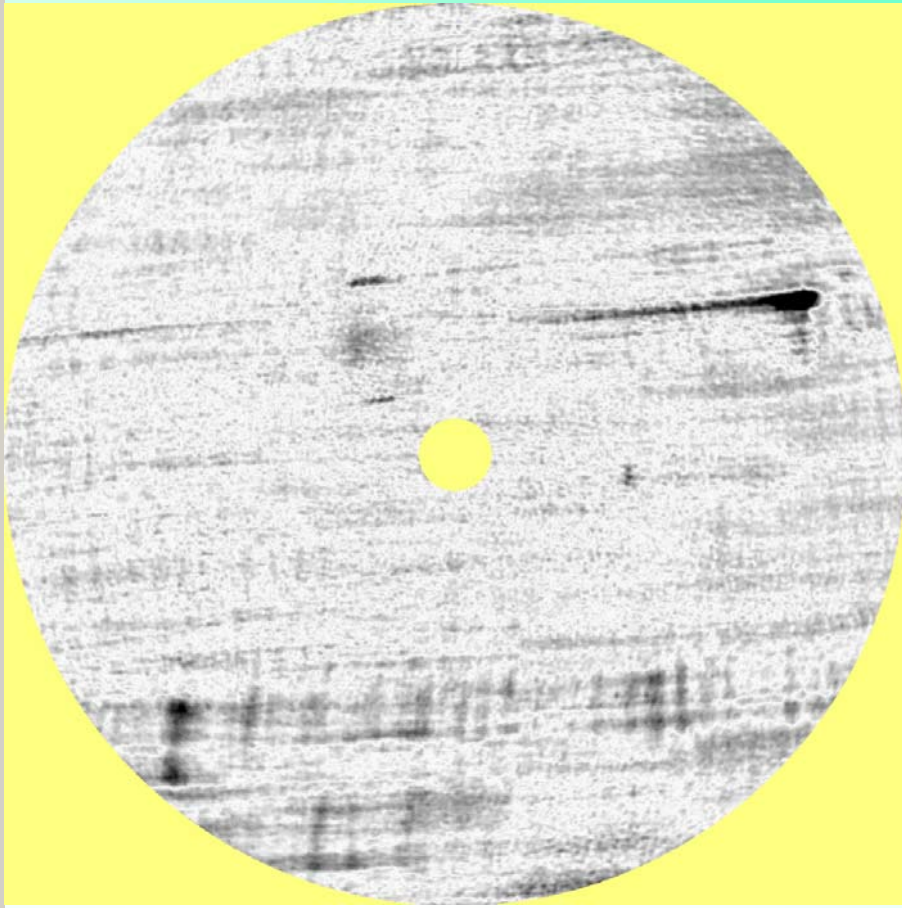
Surface image

Delomination produced during forging (sheet No. 28).

21 niobium sheets of the Fa. Tokyo Denkai has been scanned with WSK SQUID scanner.

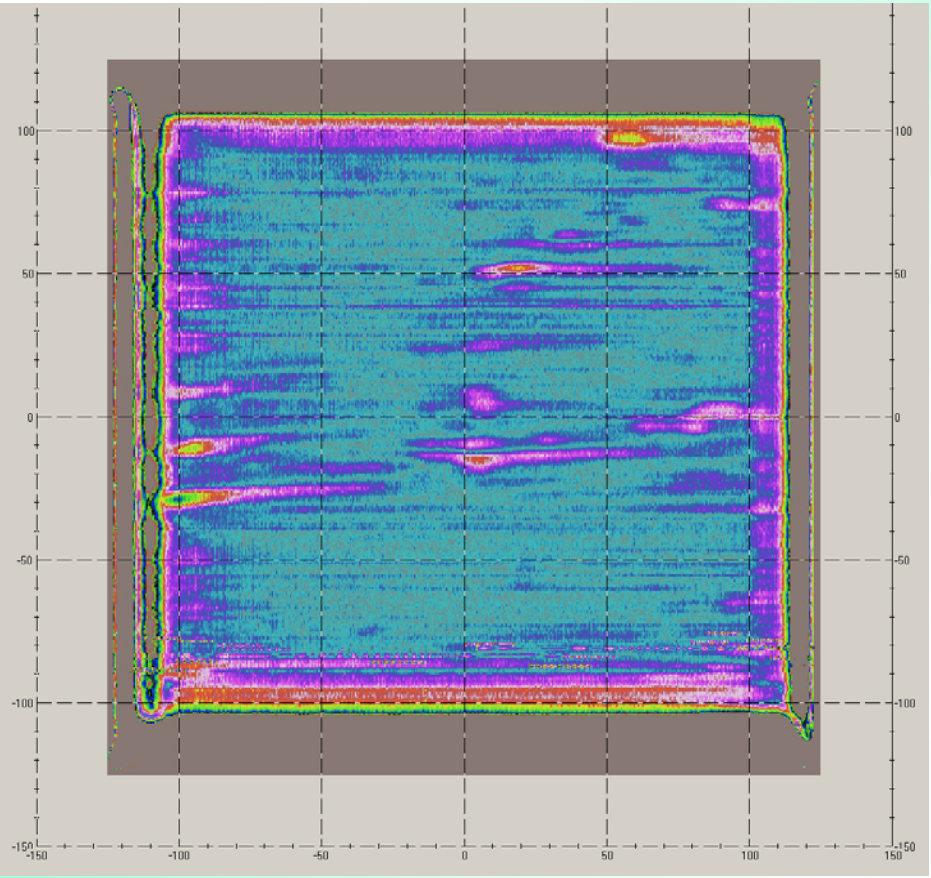
SQUID scanning results have been compared with Eddy Current scanning results get for the same sheets earlier. The sensitivity of the SQUID apparatus is at least on the same level as of the EDDY current apparatus.
Two examples of the comparison can be seen in following figures





SQUID image of the NC-1355-335 Nb-sheet

Eddy Current image of the NC-1355-335 Nb-sheet



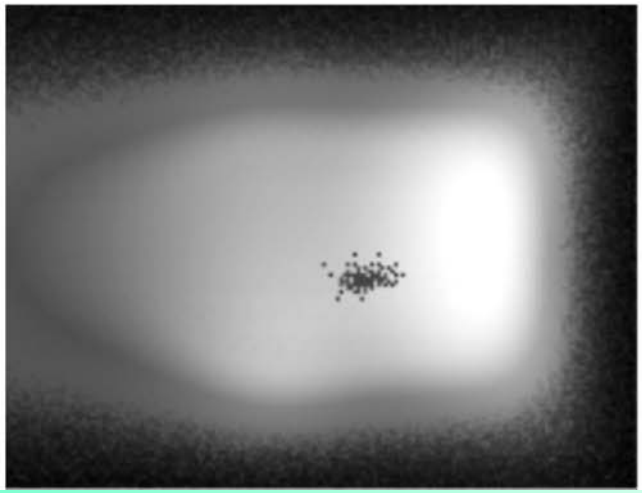
SQUID image of the NC-1357-400 Nb-sheet

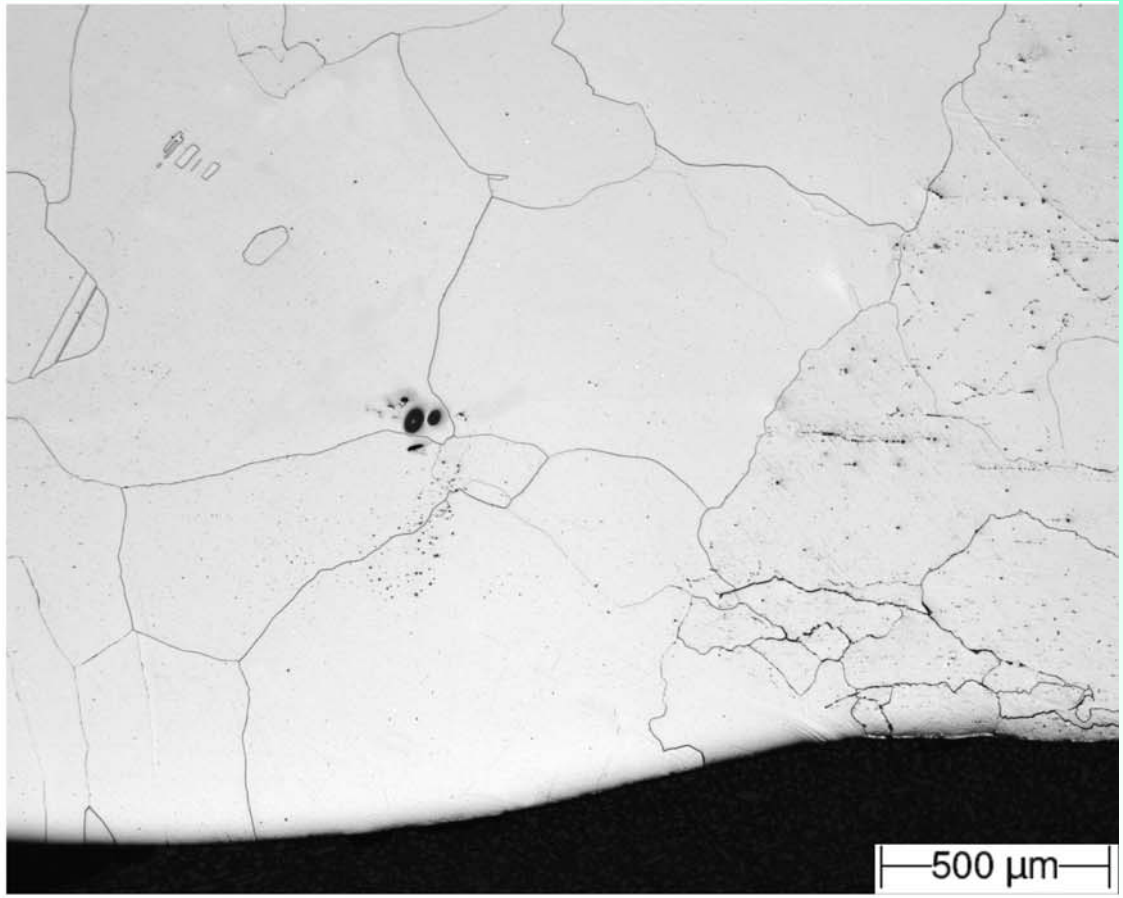
Eddy Current image of the NC-1357-400 Nb-sheet

It can be seen that for the sheet NC-1357-400 the SQUID sensor makes the potential flaws even more visible as the eddy current.

Sensitivity of SQUID Scanner

Welded seam at an Ir-sheet with shrinkage voids





Shrinkage voids of dimensions smaller as 50 µm are clearly visible. Right – microstructure in the schliff, top - welding seam, bottom - SQUID scan image

Current situation. The SQUID scanning apparatus at DESY

Summary

•The developed and fabricated at Fa. WSK SQUID scanning apparatus is in position to detect material defects of the size > 50 µm in the plane sheets with waviness < 2 mm

•The time consuming for SQUID scanning is comparable to Eddy Current devices

• Remaining tasks:

- Installation and run up of the SQUID scanning apparatus at DESY

- Identification of artificial and detected in Nb sheets defects by EDX, X-Ray fluorescence analysis etc.