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SQUID-based scanning system for detecting defects in Nb sheets for RF cavities

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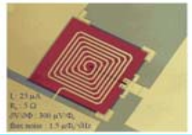
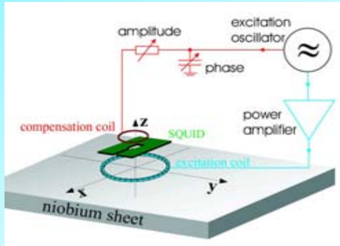
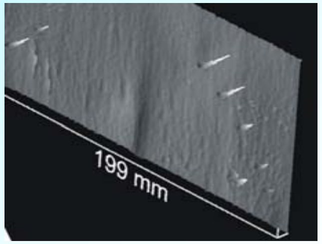
In order to evaluate the potentials of SQUID systems for Nb diagnostic a preliminary work was done in collaboration of Institute of Applied Physics, Justus-Liebig Universität Gießen, Gießen, Germany; WSK Meßtechnik GmbH, Hanau, Germany; DESY, Hamburg, Germany



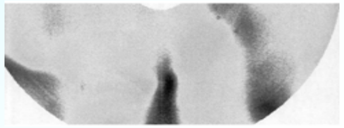
Photograph of Nb dc SQUID



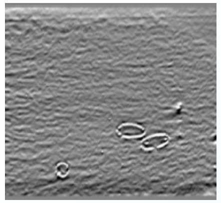
Chosen measurement configuration.
An excitation coil produces eddy currents in the sample, whose magnetic field is detected by the SQUID. A compensation coil close to the SQUID cancels the excitation field at the SQUID.



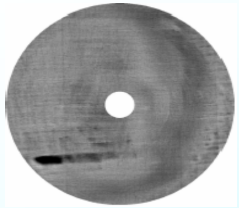
Two-dimensional distribution of the eddy-current field above a test sample containing a number of surface flaws (tantalum inclusions of size 0,1-0,05 mm close to surface) , measured with SQUID system.
Eddy current frequency 110 kHz, diameter of the excitation coil 3 mm.



Same sample, however, measured by the conventional DESY eddy current system



Scan of sheet 9 with SQUID sensor system. The three ellipses shown are pen markings for scratches (within the ellipses) on the BACK of the sheet. Some more dots and one large signal source (center left) are visible.



Scan of sheet 9 with conventional sensor system. The y-val. of channel 1 (at 170 kHz) is shown. None of the scratches is visible, as the back of the sheet is far beyond the skin depth (0.12 mm) of the frequency used.

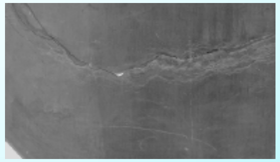
Preliminary results are encouraging **:**

SQUID method has some advantages in comparison with eddy current method

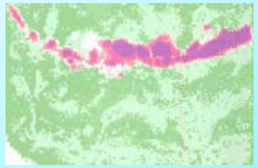
The SQUID probe is more sensitive. Particles of size smaller than 50µm, not detectable with eddy current method, are detectable with SQUID. Detection of rather deep inclusions in the material or investigation of the inside surface of closed parts (cavities) is possible . The distance between the probe and the sample surface is not so critical for SQUID method.

WSK Mess- und Datentechnik in Hanau works on development of a SQUID scanning system specially designed for testing of Nb- sheets for XFEL project (X-Ray Free - Electron Laser).

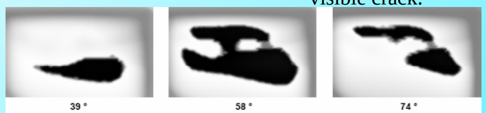
The scanner is based on a xyz table with ca. 300mm x 300mm travel area. The low TC SQUID is situated within a 1.5 l fibre glass He cryostat fixed at the z axis. The eddy current is generated by a selectable coil of diameter 1 - 3 mm. In order to maximize the resolution of the sensor the magnetic field of the excitation coil can be minimized at the sensor location by a fine adjustable compensation current. The SQUID is used with a flux compensating amplifier; the amplifiers output is then processed by a lock-in amplifier to gain the magnetic field in phase and with 90° phase shift at the location of the squid sensor. Different filters are implemented into the lock in amplifier to improve the signal/noise ratio. The lift-off effect has been minimized by the geometry of the coil. The system works in a non-shielded environment.



As an example the picture shows a lamination in a rolled Ta– sheet. On the top side of the surface no damage can be seen. On the rear side is a visible crack caused by the rolling process. A separation in the sheet can be assumed.



The ultrasonic pulse-echo analysis shows expectedly a damaged area largely matching the visible crack.



The eddy current SQUID method detected with variable phase differences not only shows the allocation of the lamination, but also the run of the separation through the material. It is also visible, that the dimension of the failure is much larger than detectable with the US method. For the detection of separations with US the size of the failure and its position in relation to the US-sensor is determining. The skew of the lamination through the Ta-sheet and its small dimension (less than 1 mm) makes the detection of such failures with US (most used for testing of such semi-finished products) nearly