Investigation of Nb Ingot Material with Large Grain for RF Cavities

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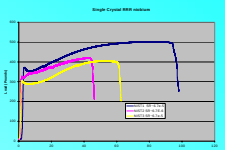
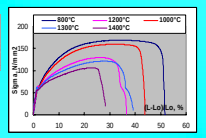
Metallurgical properties of high purity niobium discs cut from high purity niobium ingot are investigated. Main task is to check whether this option is applicable for XFEL cavity fabrication

Tensile test

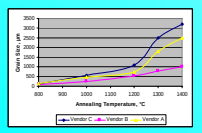


Tensile test of the sample cut from Nb ingot

Example: 60% elongation at break



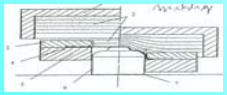
Strain-stress curves of Nb after annealing



Grain size versus annealing temperature

Grain grow in the polycrystalline Nb sheets guides by the reduction of the elongation at break. Large grain samples from Nb ingot demonstrate a very high elongation at break

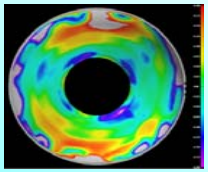
Deep drawing by one flexible tool



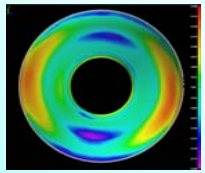
fo=1274 MHz

Half cell of TESLA shape deep drawn by one stiff and another flexible tool (polyurethane) The half cell is lick tight. The steps on grain boundaries are pronounced. Earing is pronounced (anisotropy of properties)

Optical 3D measurement of the half cell shape (accuracy ca. 20 µm)



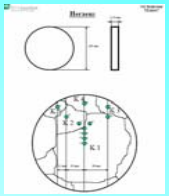
Grey areas do not meet the tolerances of +/- 0,2 mm.



The same for a half cell from standard sheet

Deep drawing method proven as best for Nb sheets seems not to be appropriate for large grain Nb discs

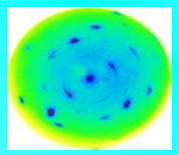
Cube orientation in large crystal



Measurement of the big crystal cube orientation. The cube orientation is represented in the stereographic projection

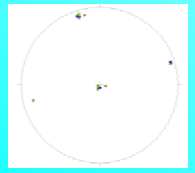
Cubic crystal

Powder

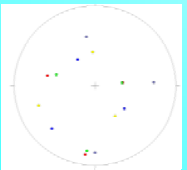


Disc of conventional Nb ingot (Ningxia, China)

Pos 11 green, Pos 12 dark blue, Pos 13 red, Pos 14 light blue, Pos 10 orange



Cube orientation in the stereographic projection for the central crystal. Reflexes of typical single crystal

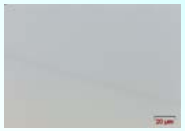


Cube orientation in the stereographic projection for the edge crystals

Pos 5 green, Pos 6 yellow, Pos 7, light gray, Pos 8 red, Pos 9 blue

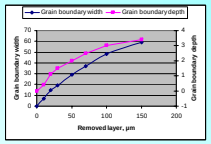
Edge crystals show a significant change of the orientations in comparison to central crystal. A big scattering of the edge crystal orientations is observed

Grain Boundary BCP 1:1:2



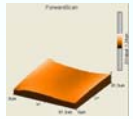
Mechanically polished, surface

Grain boundary width after 10µm BCP



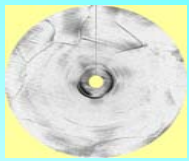
Grain boundary depth and width versus thickness of removed layer (top)

Surface profile measurement after 100µm BCP (right). Profile peak height and valley on grain boundary can be seen



Mechanically polished, surface, AFM image

After 150µm BCP

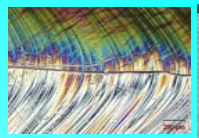


Eddy current scanning image of the Nb disc from HERAUS ingot (grain boundaries are pronounced)

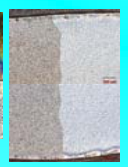
	Oxygen Wt. ppm	Nitrogen Wt. ppm	Hydrogen Wt. ppm	RRR
Grain	8.9 +/- 0.9	1.7+/- 0.5	2.7+/-01	322
Grain boundary	9.1+/- 0.1	3.1+/- 0.2	2.3+/-0.1	246

Gas content and RRR in the grain and grain boundary areas

EB welding of two differently oriented large grains from Nb ingot



Surface of the welding seam; not polished



Cross section

Cross section

Surface

It seems that after EB welding of two differently oriented Nb single crystals the grain boundary between them remains, although it is very tight