Niobium Production at Tokyo Denkai

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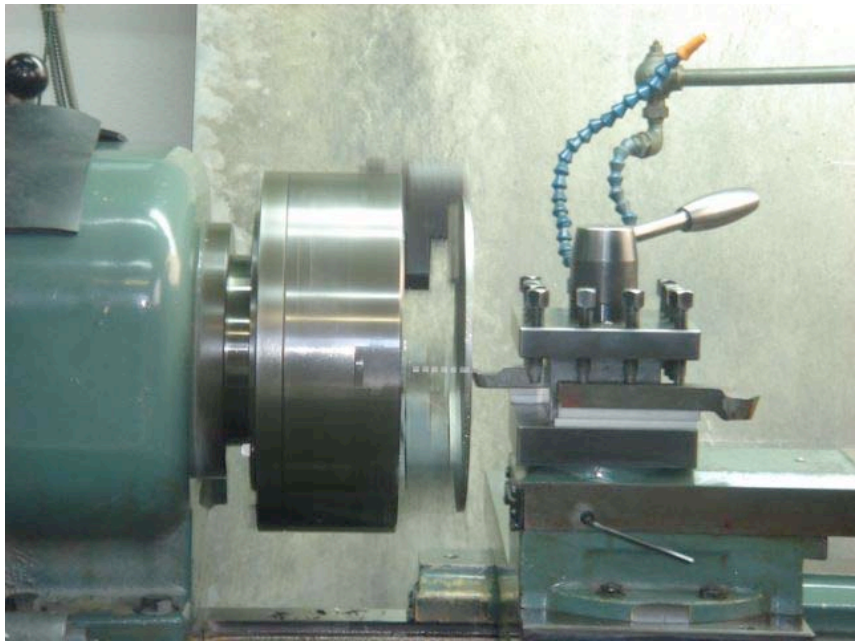
Agenda

- Multi-wire Saw Slicing
- Ultrasonic Imaging
- Single Crystal Experiment
- Summary

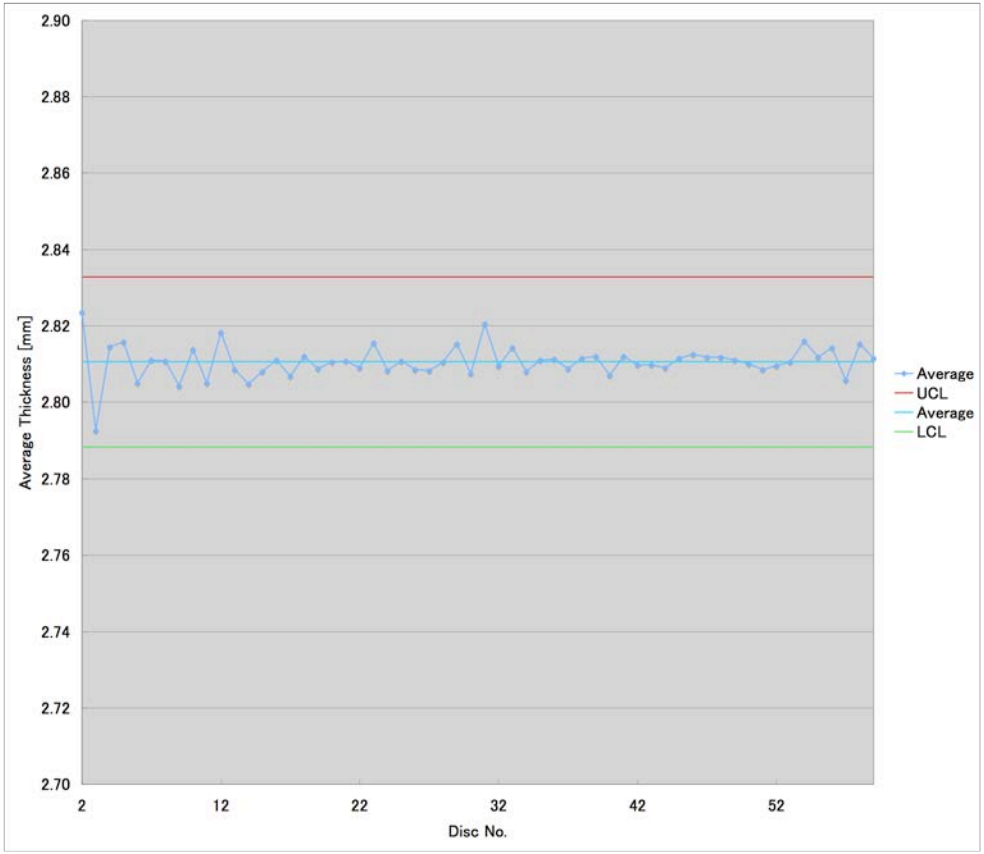
Production cost of sliced Nb discs is high

- Saw an ingot (5mmt) + turn it off
  - 5 hours + 1hours = 6hours/disc



Multi-wire saw (MWS) slicing

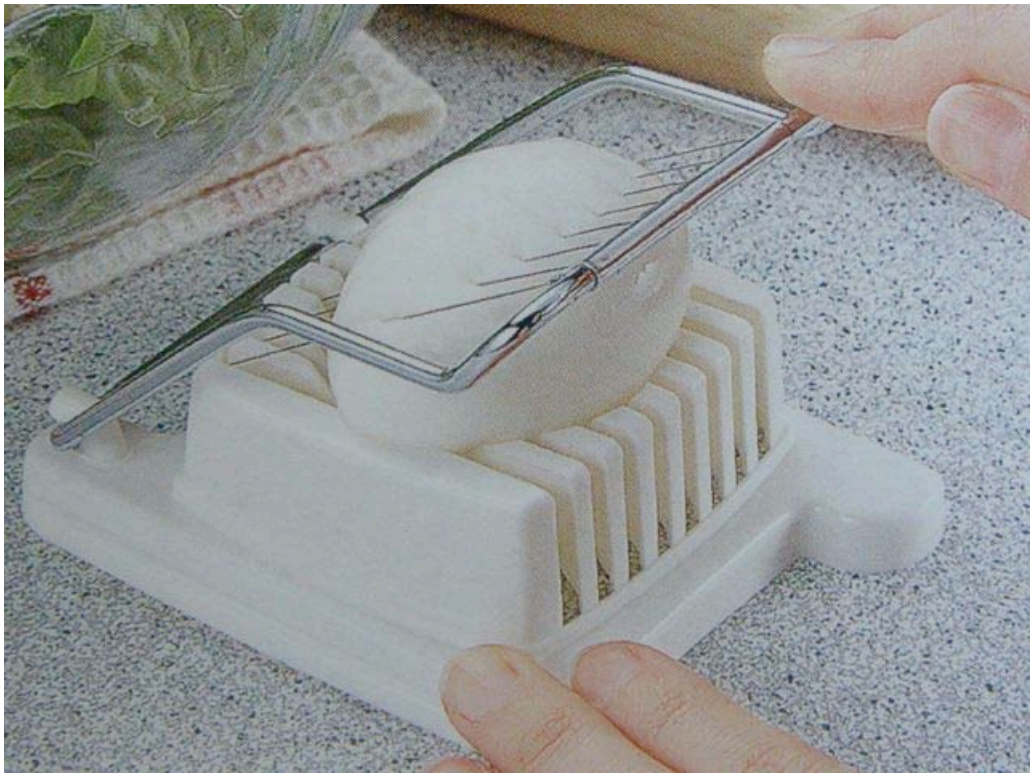
Uniform Thickness



Average = 2.811 (n = 232)
Standard Deviation (σ) = 0.0074
UCL (Ave + 3 σ) = 2.833
LCL (Ave − 3 σ) = 2.788 (unit: mm)

Principle of MWS

- The wire saw operates on the same principle as an egg slicer.



Differences between MWS and egg slicer

Item	Egg slicer	Multi-wire saw
Object	egg	Nb (original object: Si)
How many sliced?	8 pcs	150pcs (2.8mm thickness)
Required Time for slicing	1 sec	54 hours
capital investment	¥100 $1.17	¥100,000,000 $1,176,470.59

$1.00=¥85

Production cost of sliced Nb disc

MWS

- Speedy! 150 pcs of 2.8 x 265 ø in 2 days
- Excellent uniformity of thickness (+/−7 um).
- However, machine is expensive
  - US$1,176,00 （including building）

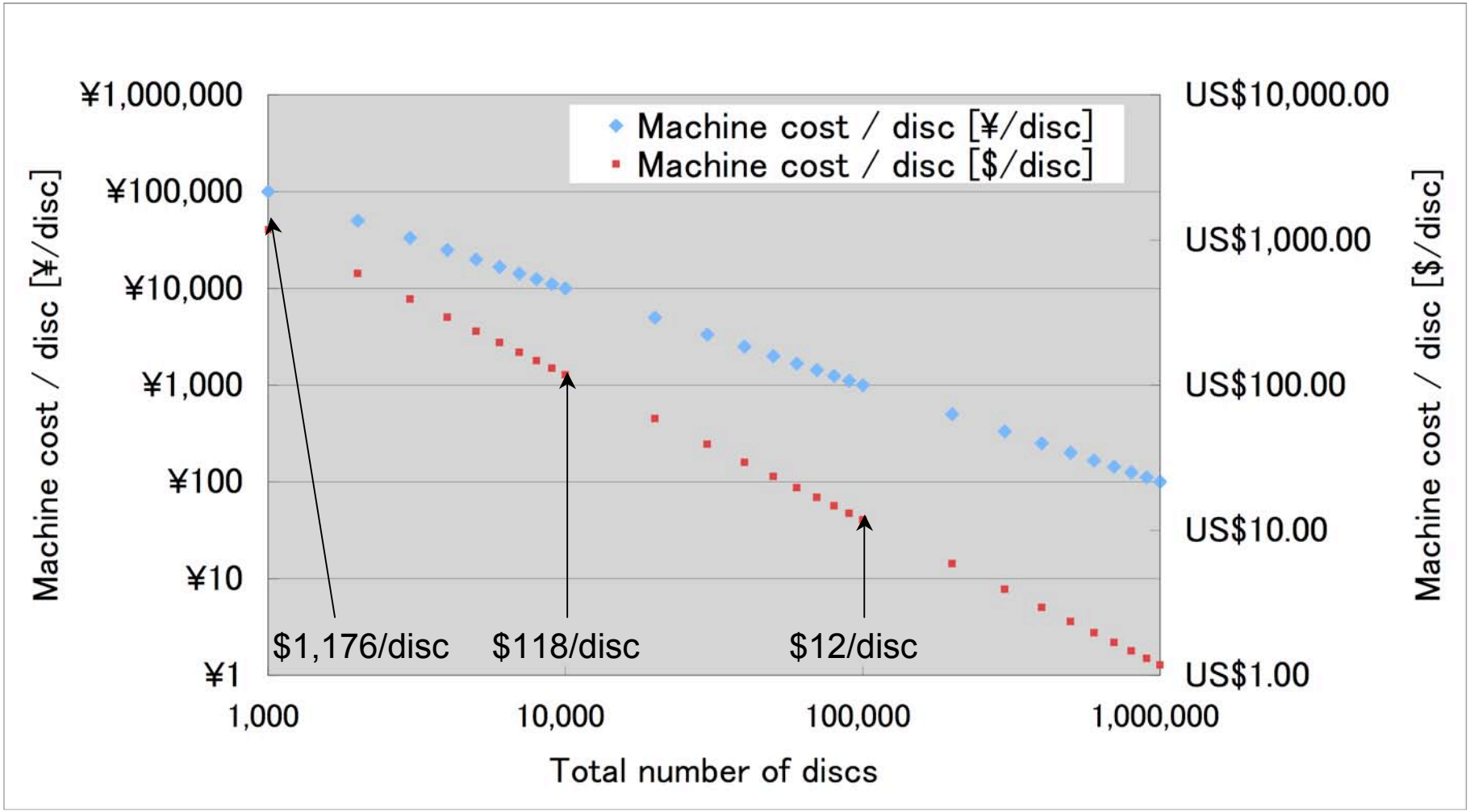
– 1,000 discs (1 x 10^3) $1,176/disc (equipment cost)

– 10,000 discs(1 x 10^4) $118/disc (equipment cost)

– Production cost of disc = ingot + slice fee

– Slice fee = equipment cost + running cost

Machine cost per slice



Recouping our investment is difficult.

Ultrasonic Imaging System

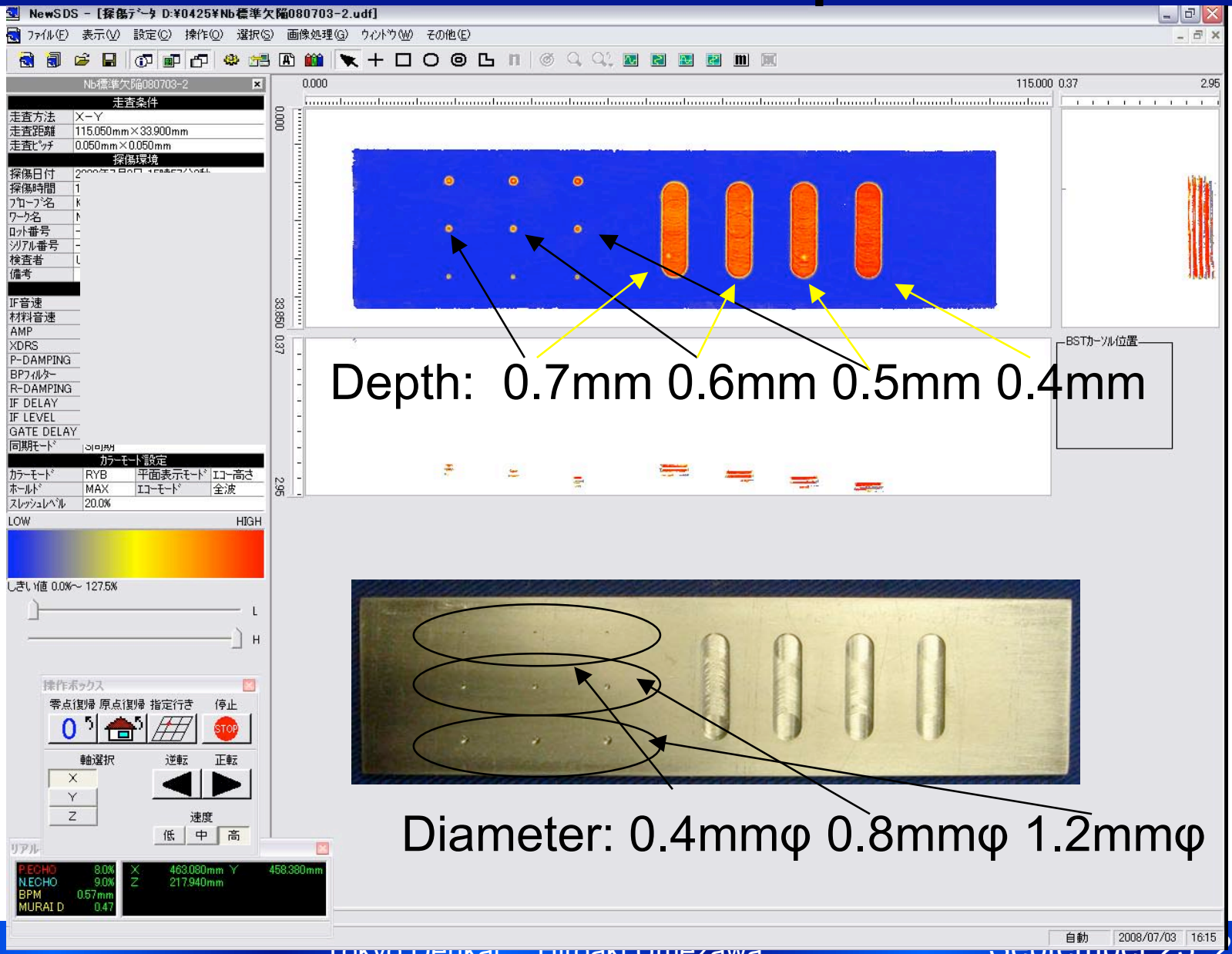
Wavelength

Longitudinal wave（Compression wave）

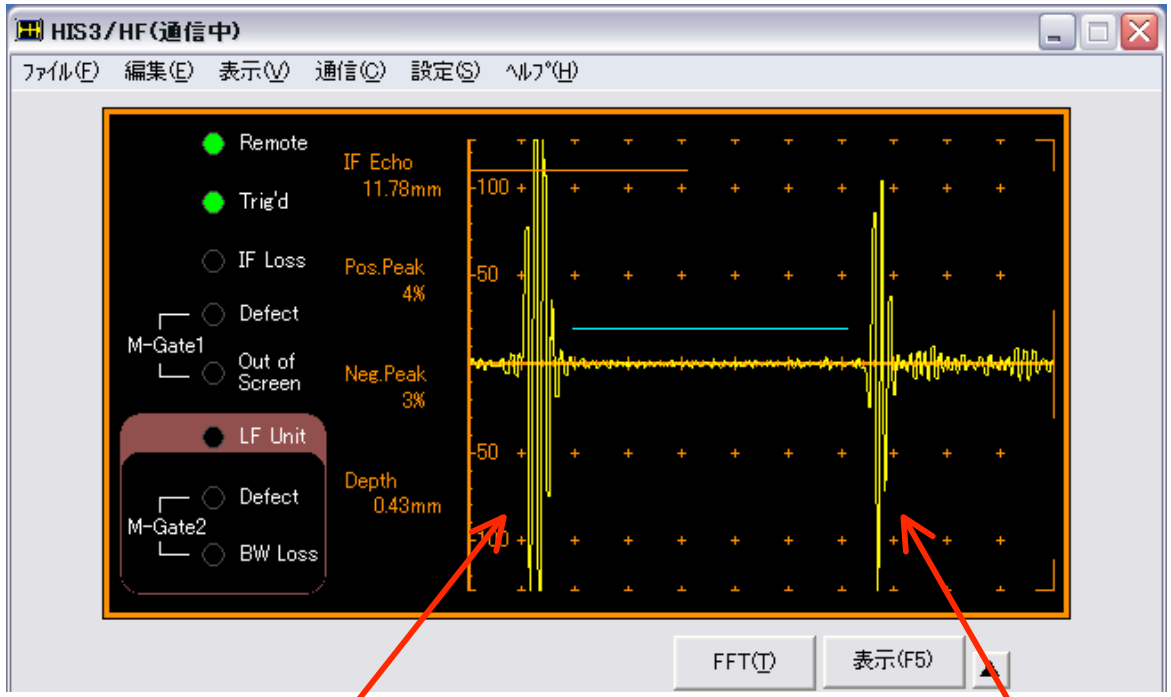
	Unit	Water		Nb	
Frequency	MHz	35	80	35	80
Sonic speed	m/sec	1680		5100	
Wavelength	m	4.80E-05	2.10E-05	1.46E-04	6.38E-05
	mm	4.80E-02	2.10E-02	1.46E-01	6.38E-02
	μm	48	21	**146**	**64**

Wave Length

Artificial defect sample of Nb



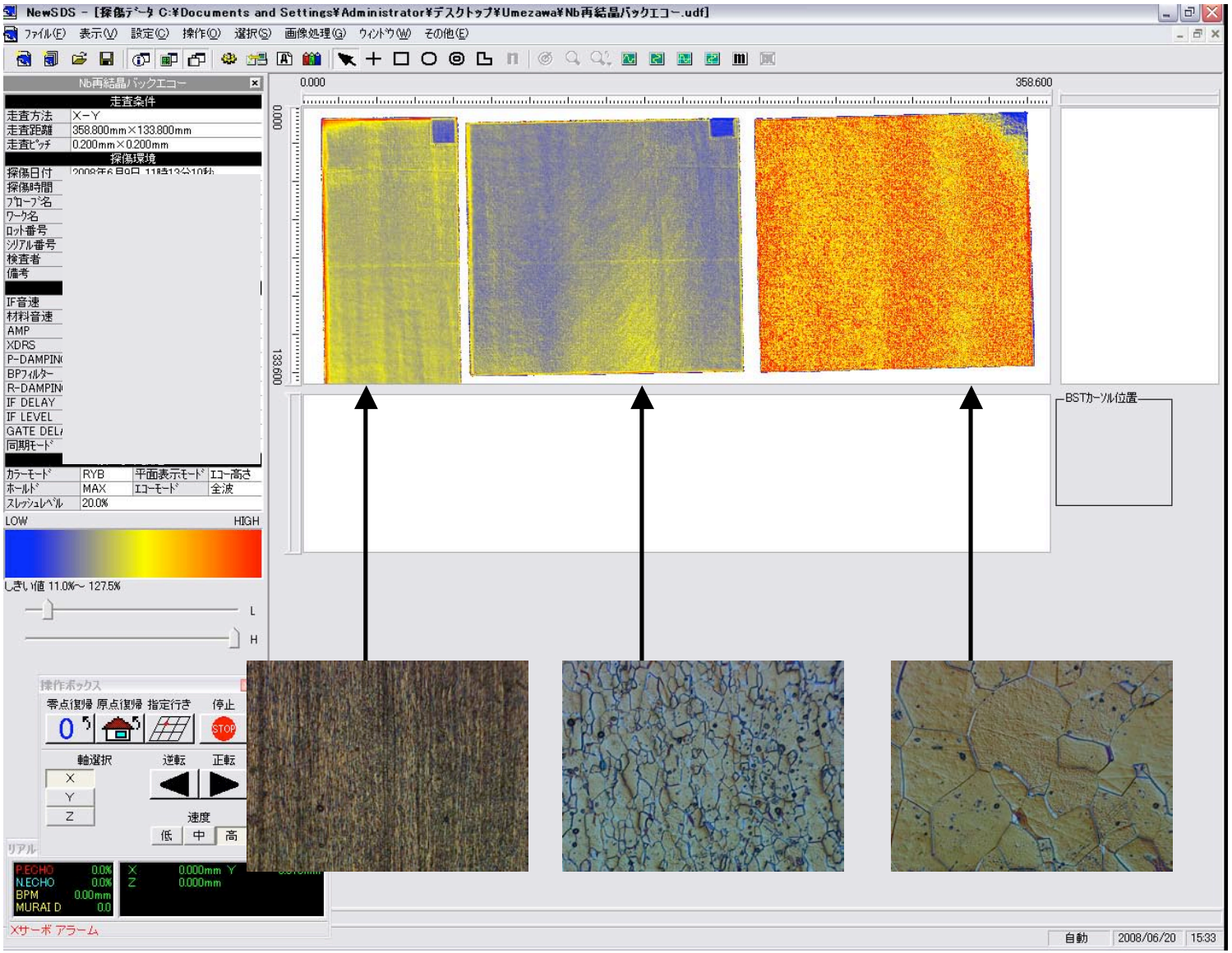
A-Scope



Surface Echo

Back Echo

Grain size


NewSDS - [探傷データ C:¥Documents and Settings¥Administrator¥デスクトップ¥Umezawa¥Nb再結晶バックエコー.udf]
Nb再結晶バックエコー
走査条件
走査方法 X-Y
走査距離 358.800mm×133.800mm
走査ピッチ 0.200mm×0.200mm
探傷環境
探傷日付
探傷時間
プローブ名
ワーク名
ロット番号
シリアル番号
検査者
備考
IF音速
材料音速
AMP
XDRS
P-DAMPIN
BPフィルター
R-DAMPIN
IF DELAY
IF LEVEL
GATE DEL
同期モード
カラーモード RYB
平面表示モード エコー高さ
ホールド MAX
エコーモード 全波
スレッシュレベル 20.0%
LOW
HIGH
しきい値 11.0%~ 127.5%
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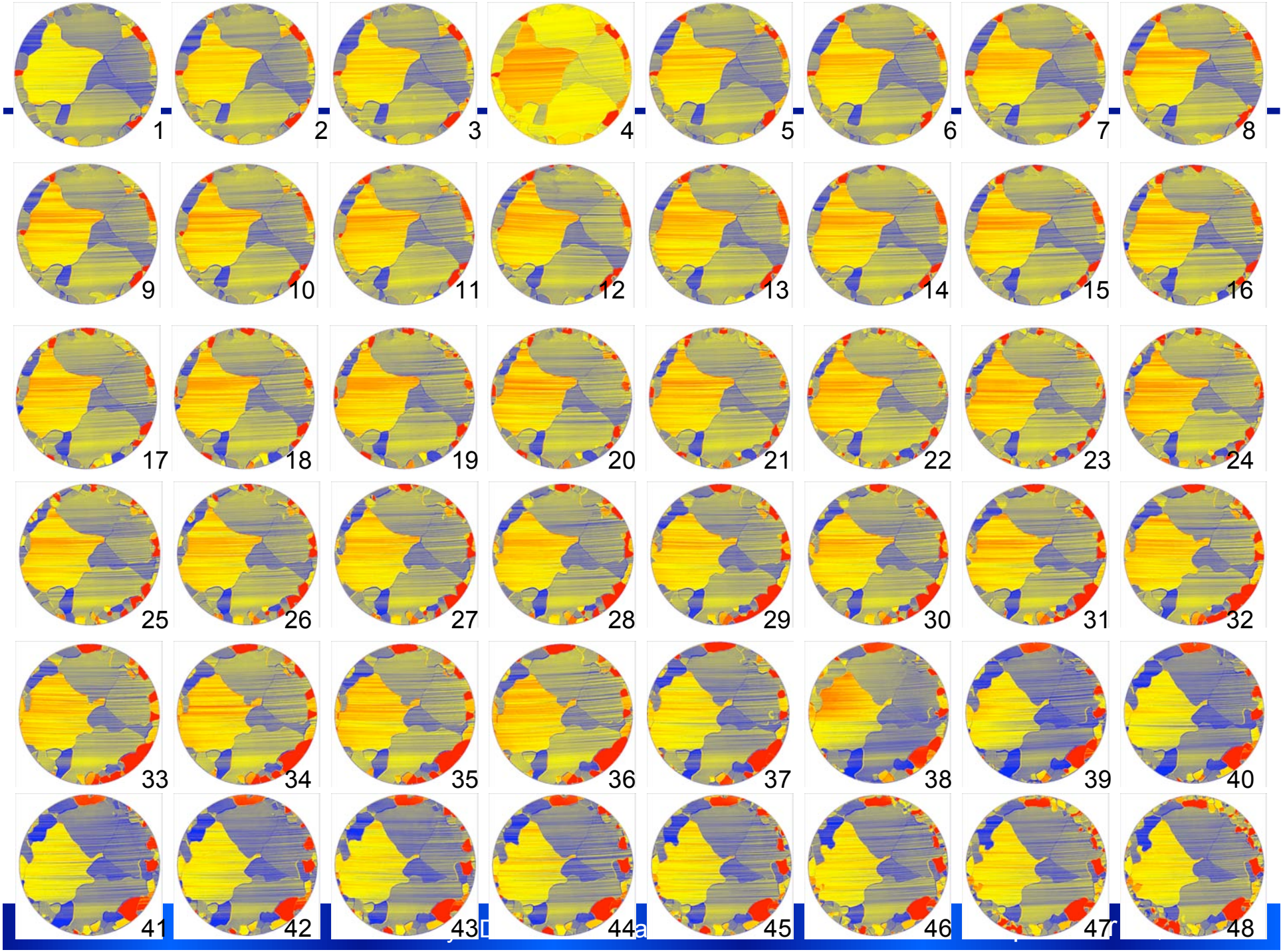
H
0.000
358.600
0.000
133.800
BSTカーソル位置
操作ボックス
零点復帰 原点復帰 指定行き 停止
STOP
軸選択
X
Y
Z
逆転 正転
速度
低 中 高
P.ECHO 0.0%
N.ECHO 0.0%
BPM 0.00mm
MURAI D 0.0
X 0.000mm Y
Z 0.000mm
Xサーボ アラーム
自動 2008/06/20 15:33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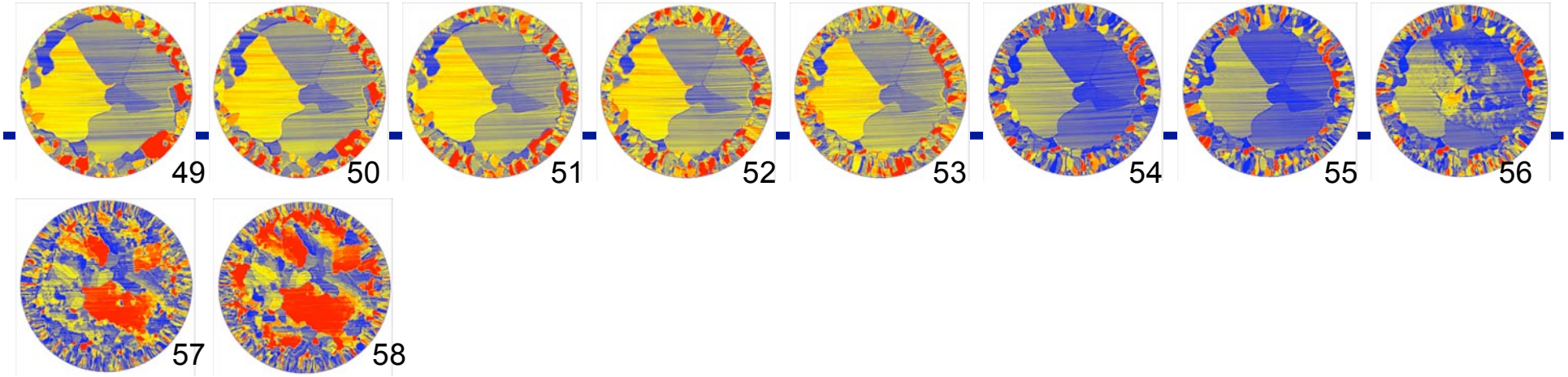
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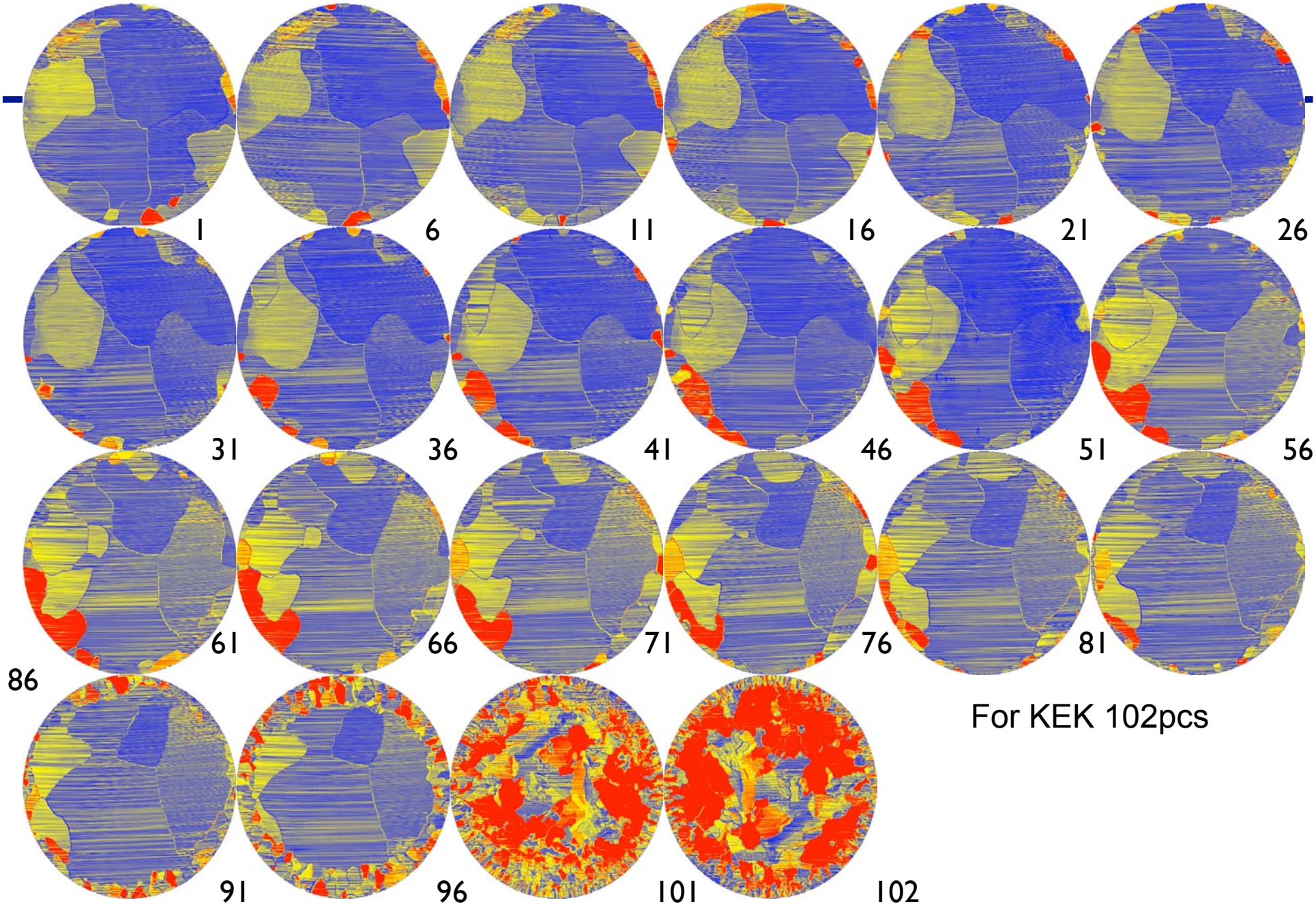
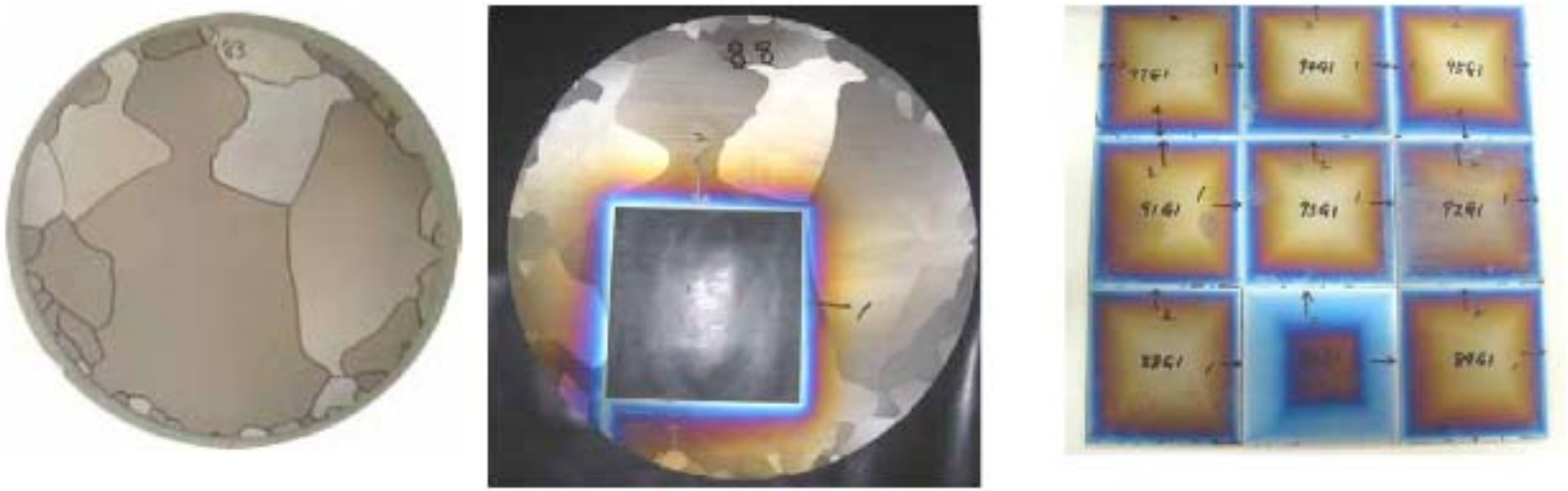


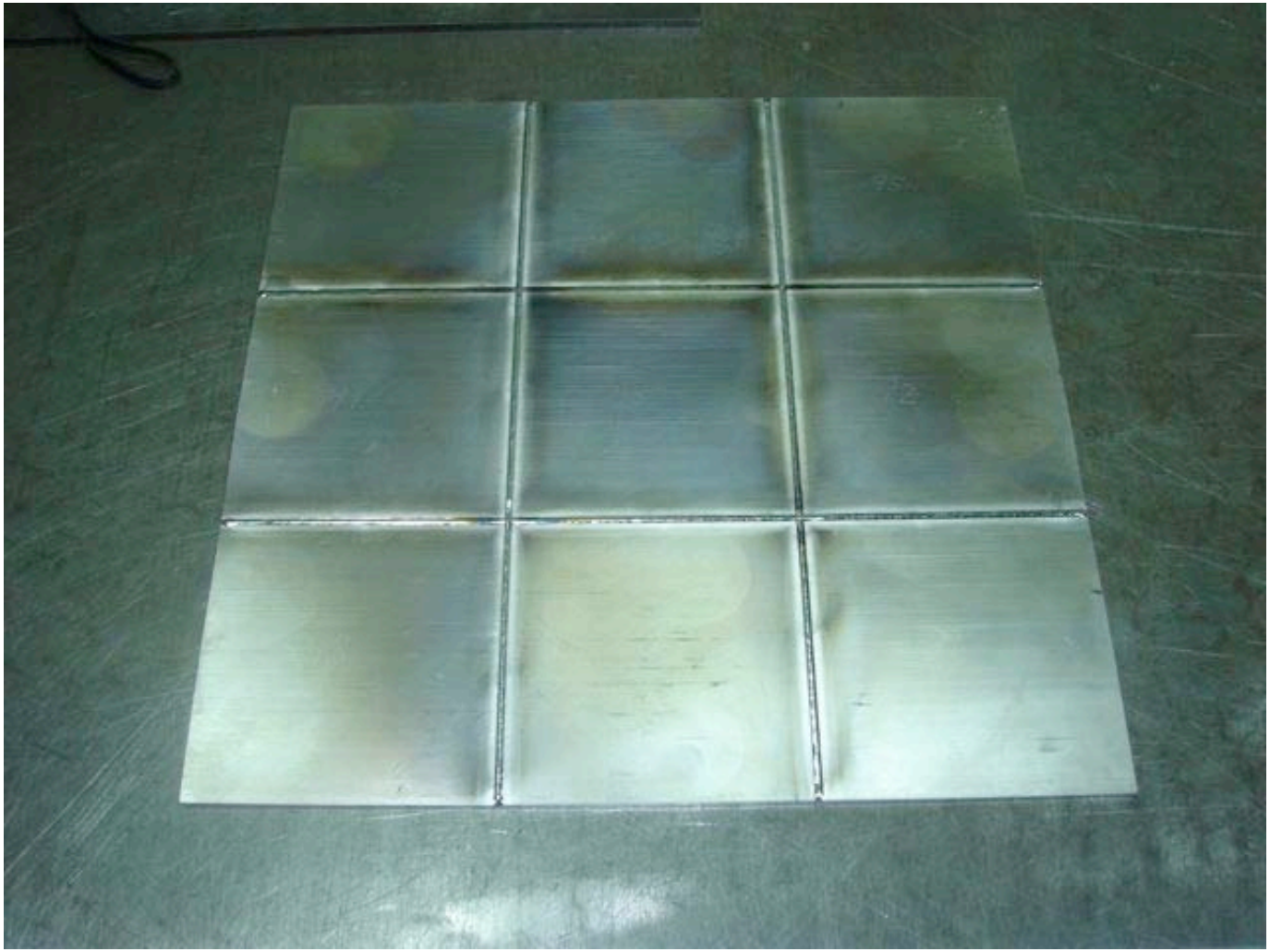
For KEK 102pcs

Single crystal seed experiment

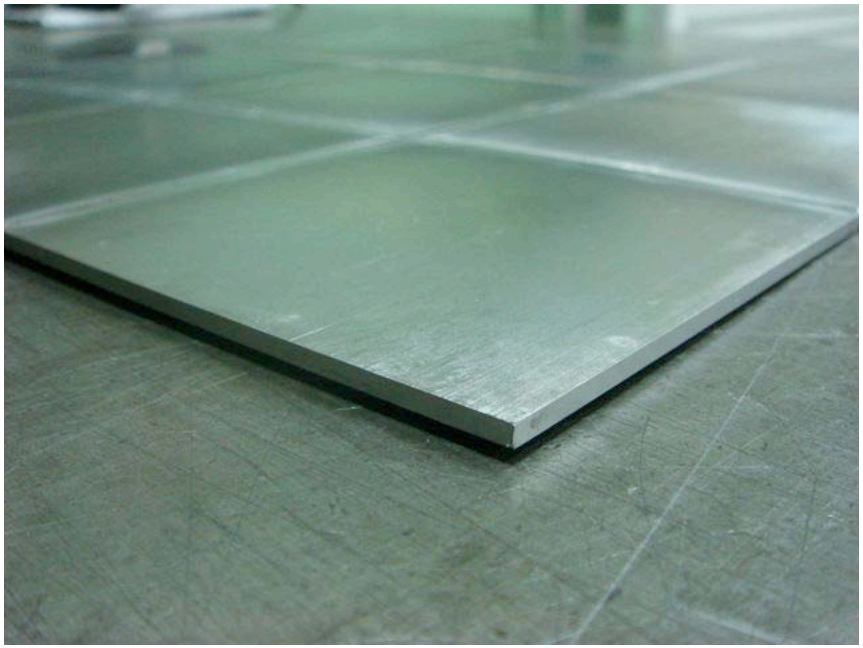


Sample was prepared by KEK.

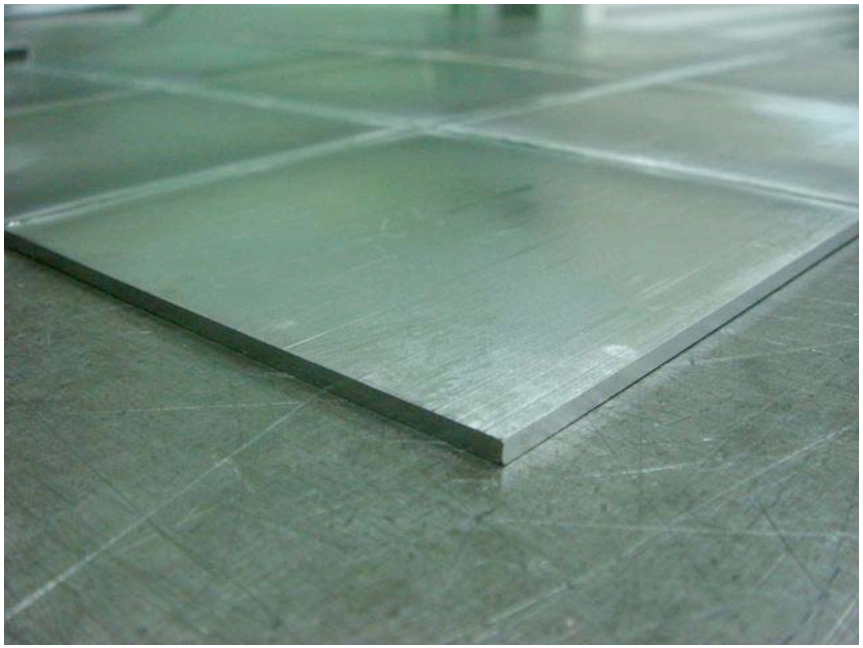
As received



Flattening the sheet

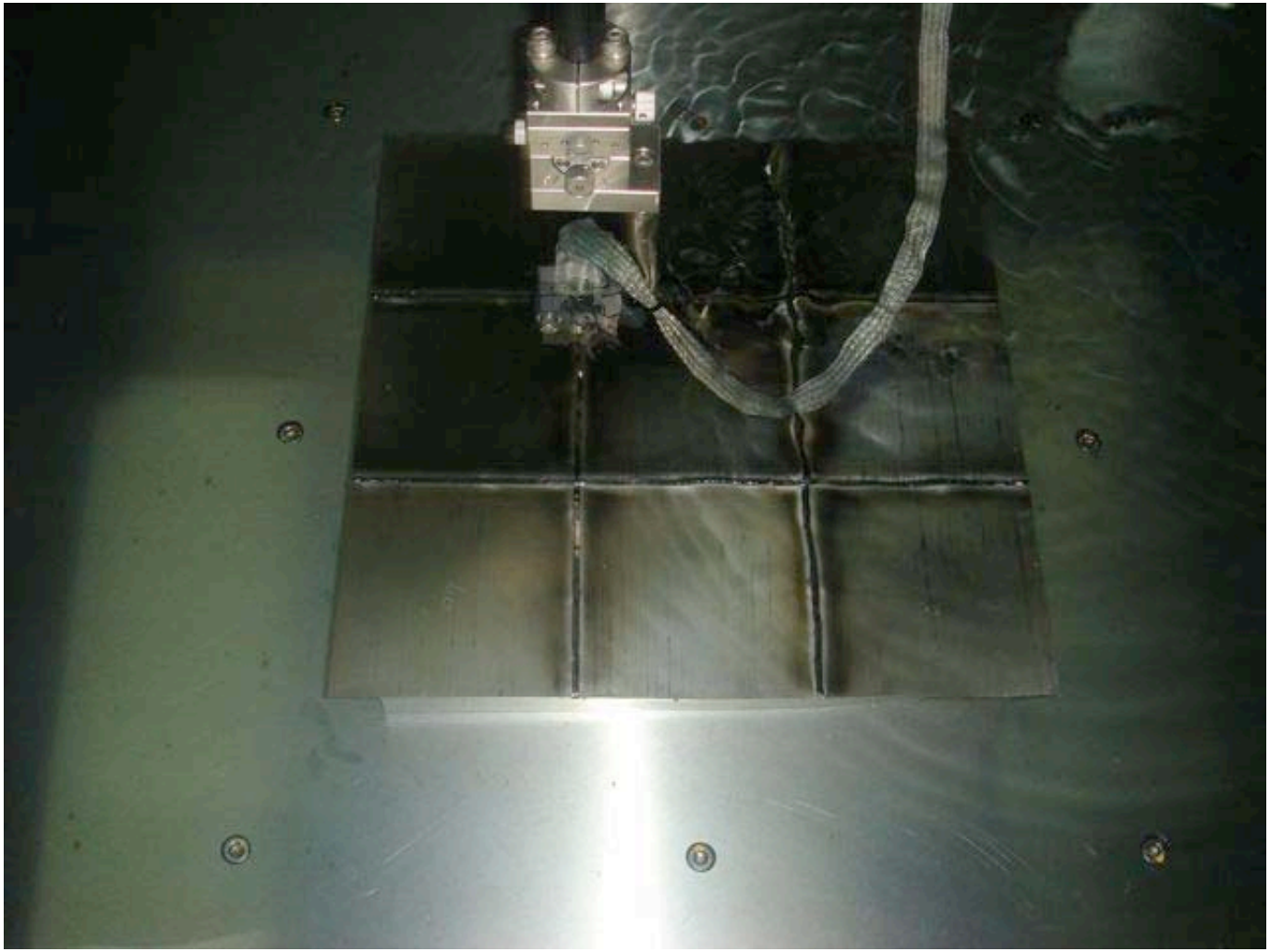


Before

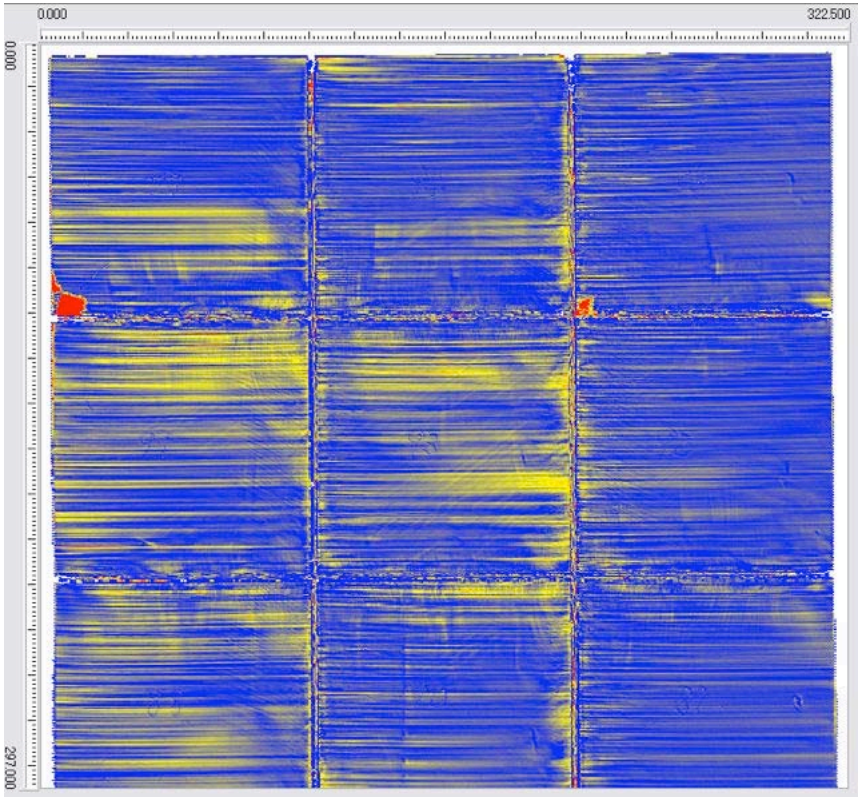


After

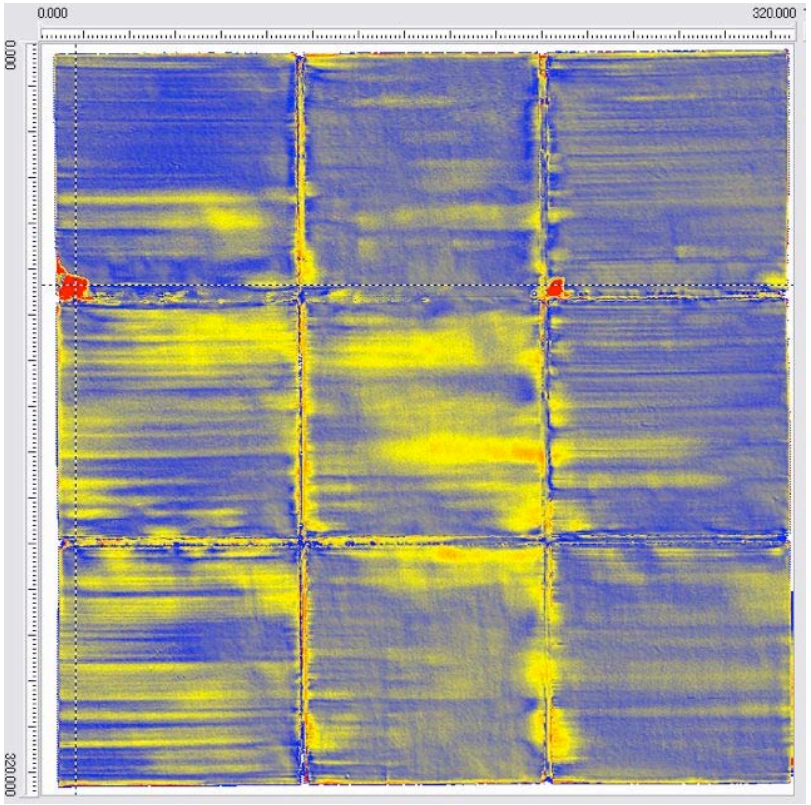
Ultrasonic imaging



Ultrasonic imaging result



As received
Wire saw traces can be seen.

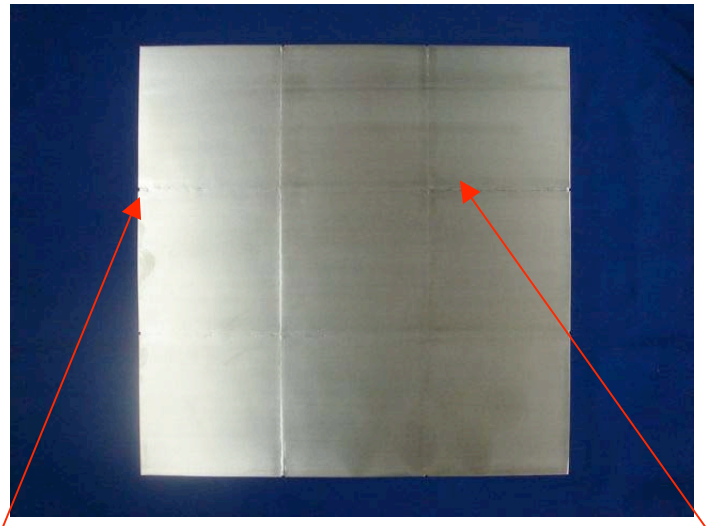


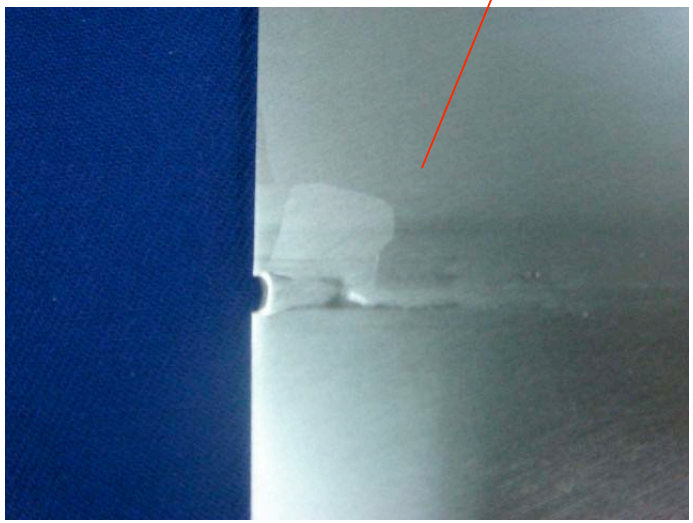
After buffing and BCP

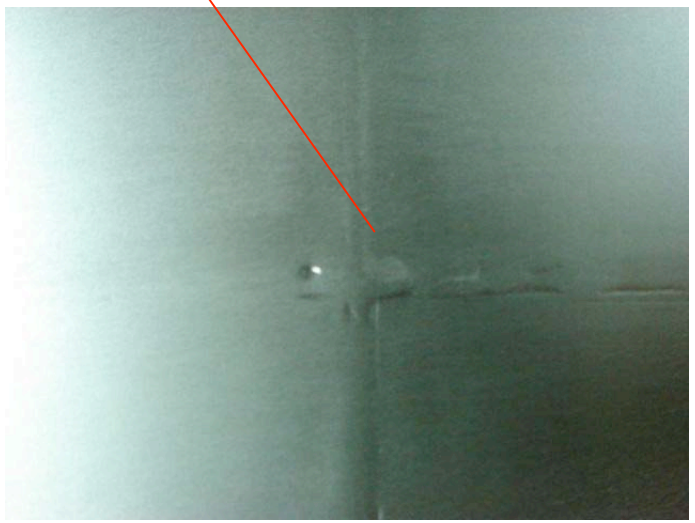
Two other crystal orientations are observed.

Naked-eye inspection after buffing & BCP

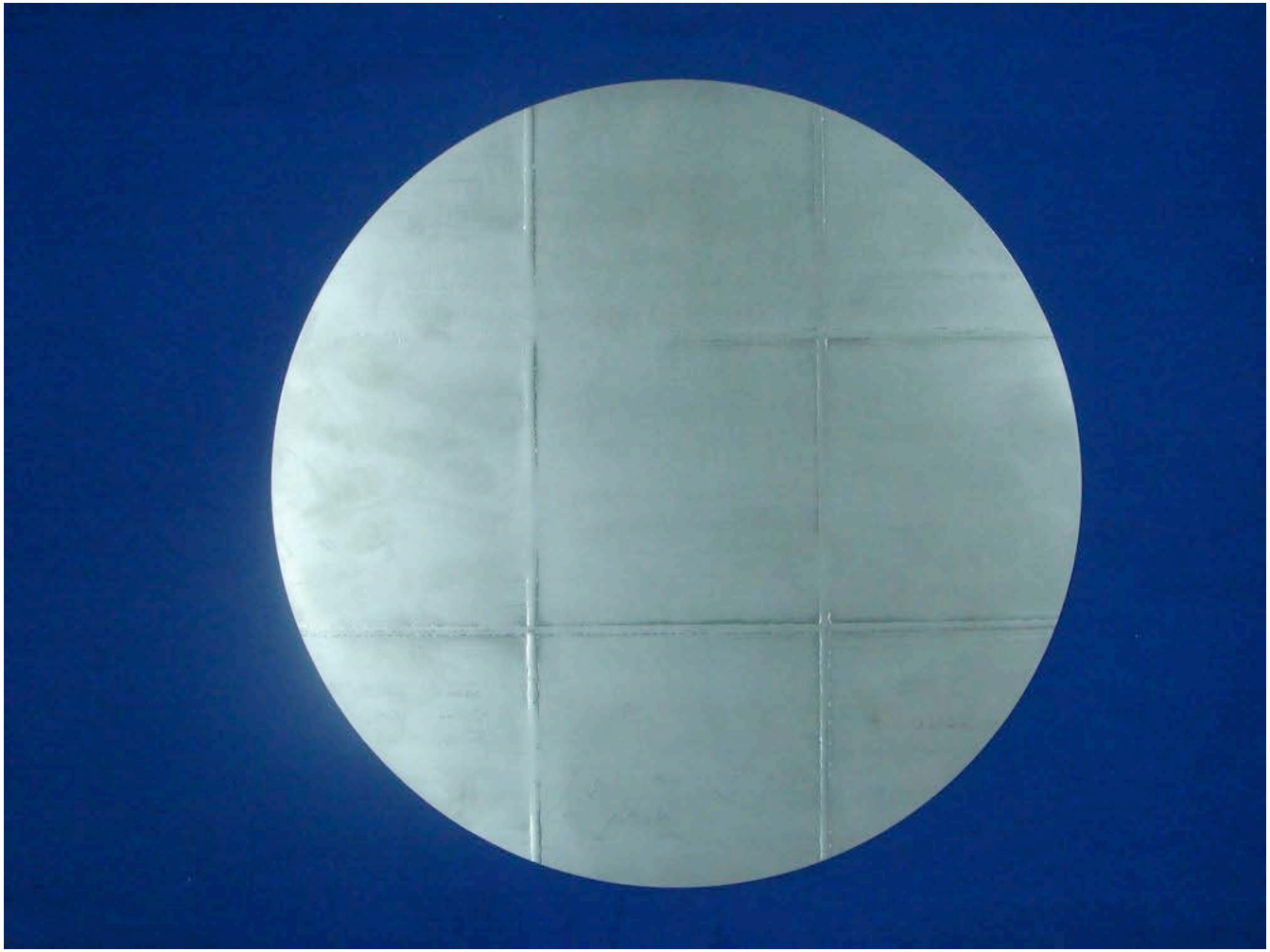
Grain boundary can be seen by naked eye at the place indicated by ultrasonic imaging.



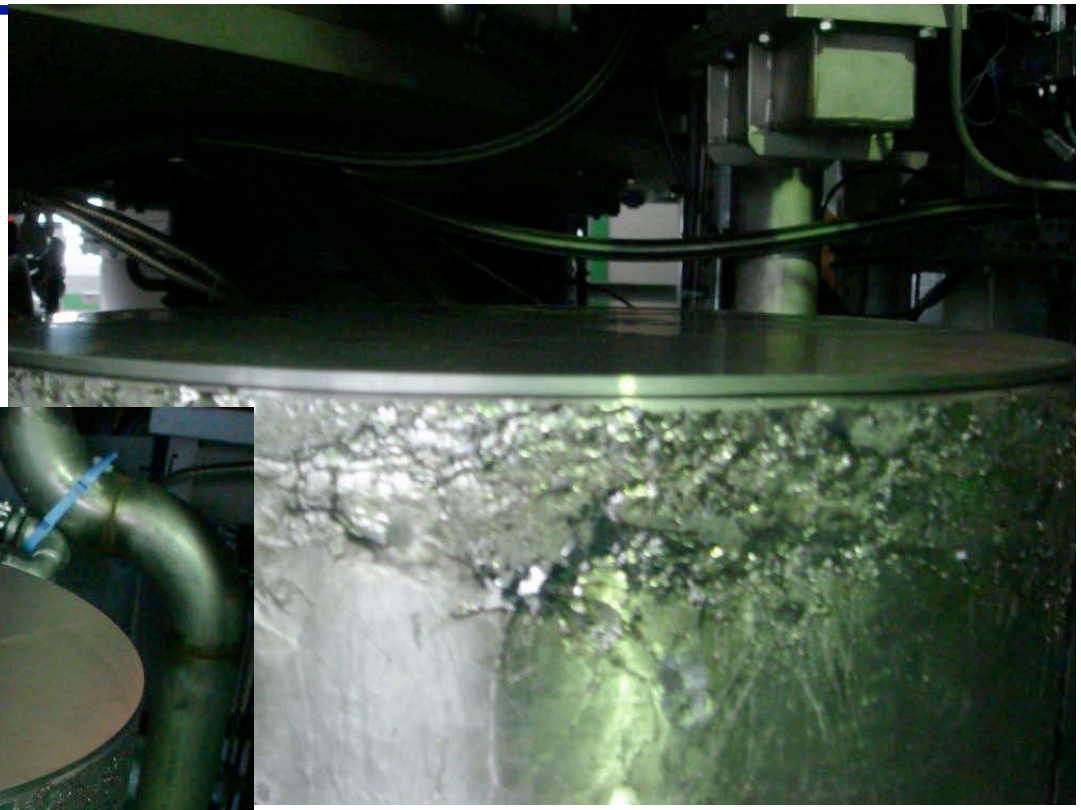


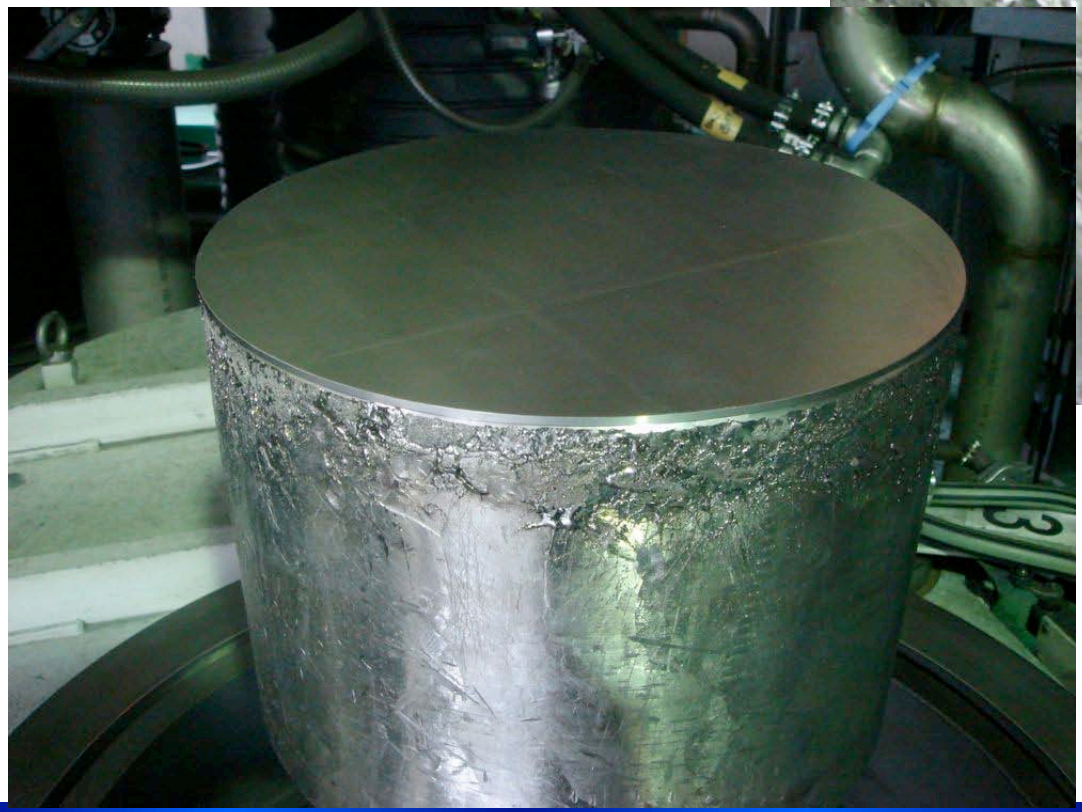


Single crystal seed

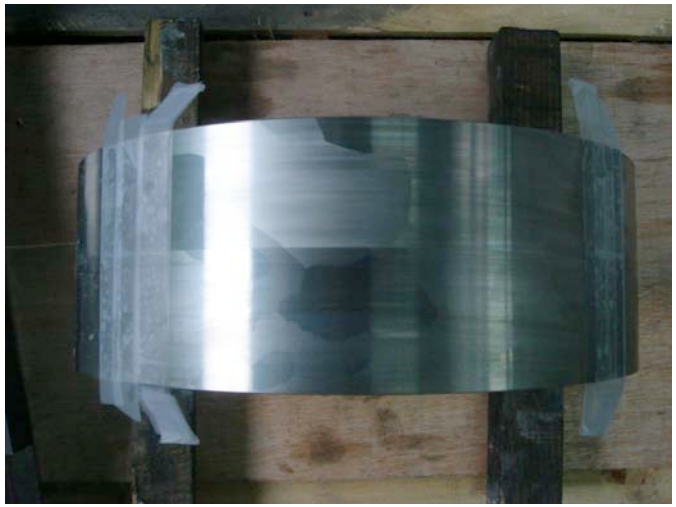


Set the seed to ingot base plate

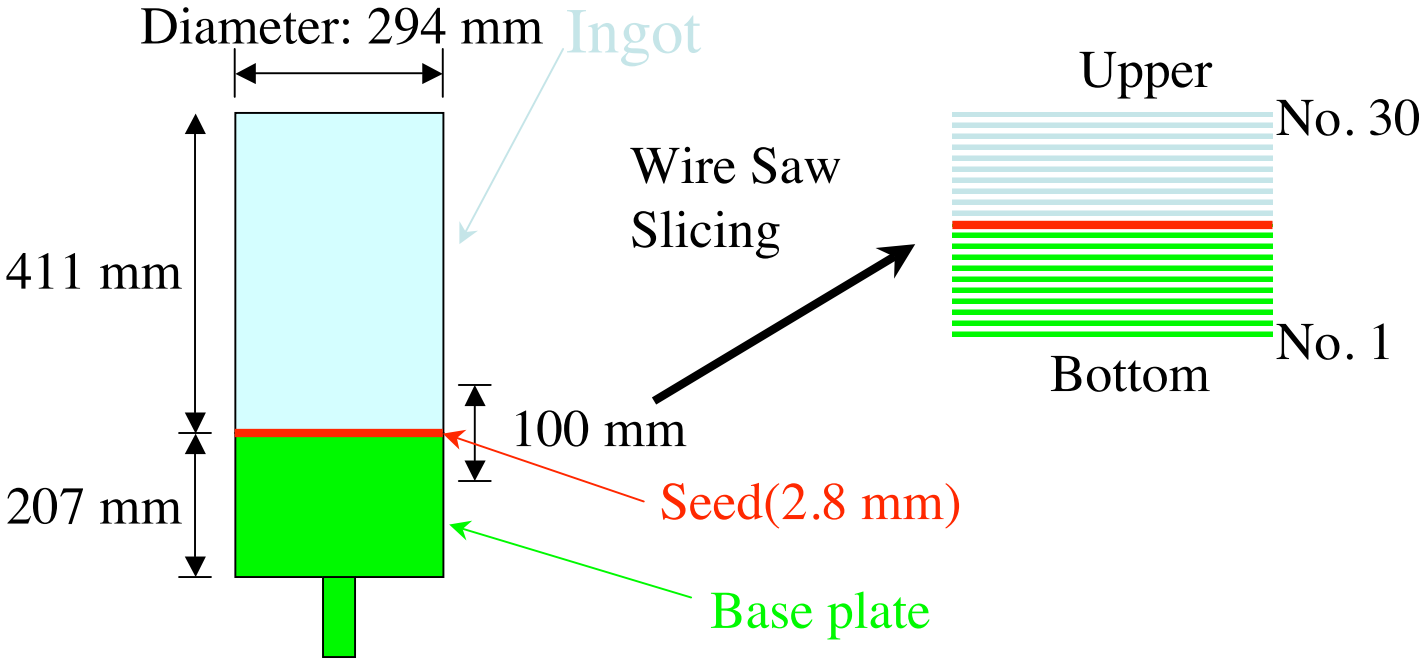


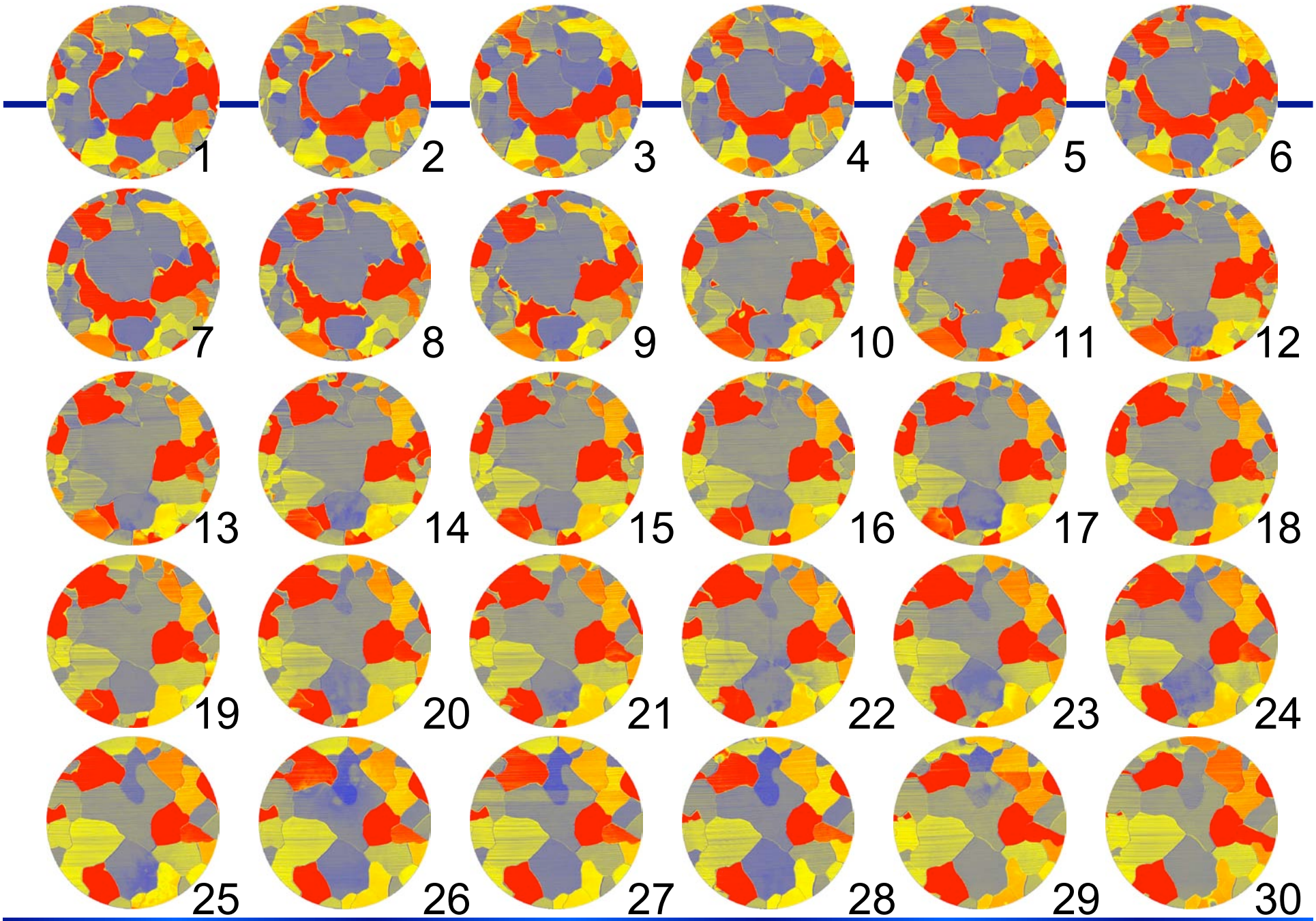


Test the material after melting



100 mm slice (seed is at the center)

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Summary (single crystal examination)

- We observed the crystal's shape at various positions from base plate to ingot, including the seed material's position. The crystal's shape changed continuously.
- At the seed position, No. 17, we found no trace of the single crystal.
- Crystal orientation had moved from the base plate.
- During melting, at the moment EB hit the seed material, the seed curled like a potato chip. A hole also appeared at its center.
- We learned from this experiment that the seed was not sufficiently thick.

Summary (cost of wire saw slicing)

- Production of large-grain Nb discs using MWS slicing is not cheap owing to the machine cost.
- As the amount produced increases, the production cost decreases.
- If 10,000 pcs of sliced disc are produced, the machine cost per disc is about $118.
- Production cost of LG discs depends on the demand.

Summary (FG or LG)

- Fine-grain Nb or large-grain Nb?
- Which technology will be chosen for the SC cavity material in the ILC project?
- How would I know?
- I inform you that Tokyo Denkai produces discs using both these methods.