Multi-Wire Slicing of Large Grain Ingot Material

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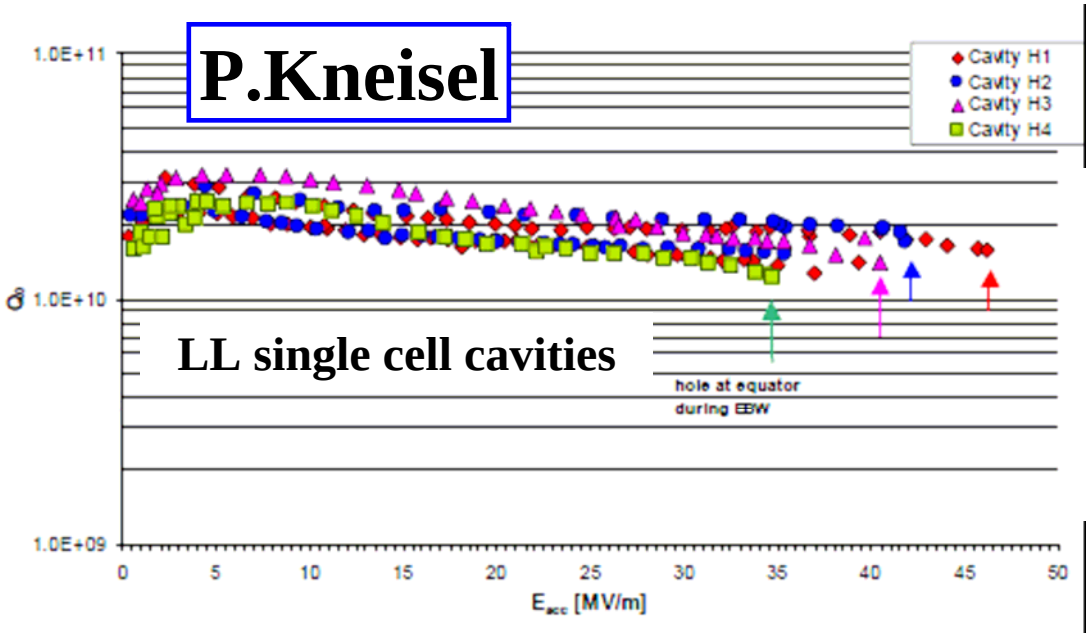
This is a collaborative R&D with Tokyo Denkai.

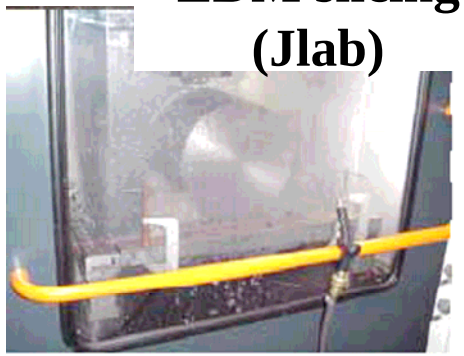
- **Multi-Wire Slicing**
- **R&D of the Multi-Wire Slicing**
- **Feature of the Multi-Wire Slicing**
- **Just Started 9-Cell Cavity Evaluation**
- **Summary**

Large Grain Cavity Performance and Its Sheet Production



The strategy: L.G. material + LL shape + BCP is very much promising.

EDM slicing (Jlab)



Sliced one by one
48hr
Time consuming

Sawing (NingXia, Tokyo Denkai)

\+ **Mechanical surface finishing**

Time consuming and Lots of material waste

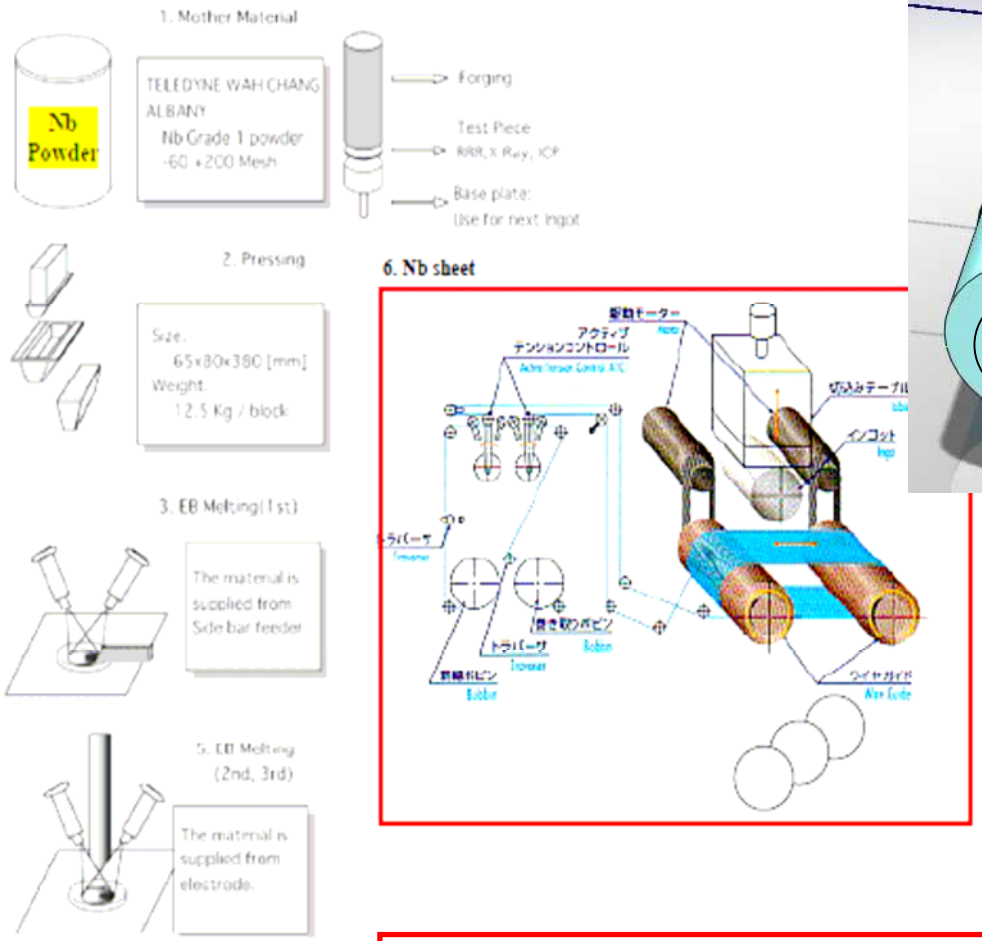
For the realistic production,

a problem is Nb ingot slicing!!

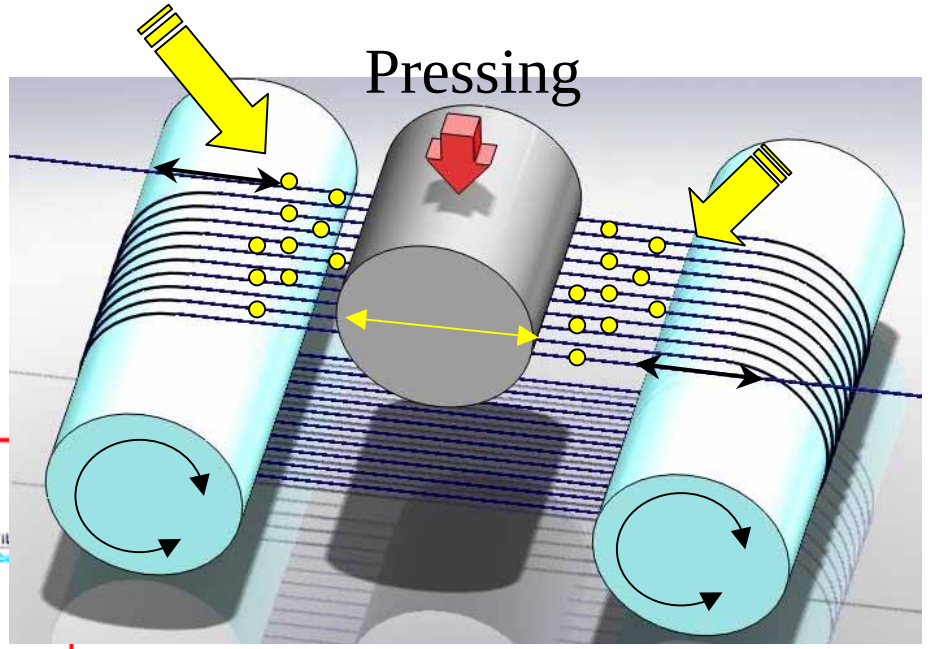
Multi-Wire Slicing Method

K.Saito

Single Crystal-Large Grain Niobium Technology Workshop in Brail 2006



Splay liquid abrasives

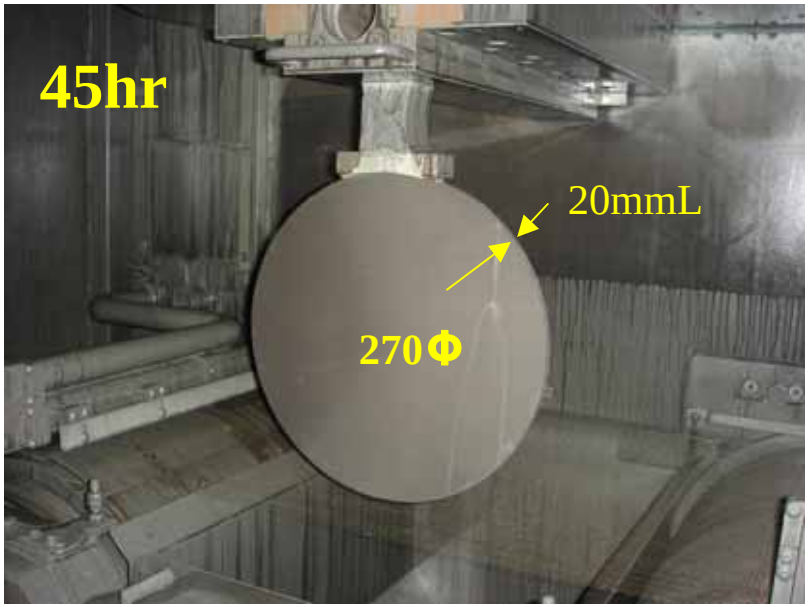


Slicing used very thin piano wire (0.16Φ) and liquid abrasive

This technology is established technology on silicon wafer slicing. However, the experts had very critical opinions about my idea.

R&D of Multi-Wire Slicing @ KEK/Tokyo Denkai

The first trial for niobium ingot slicing after small sample cuttings

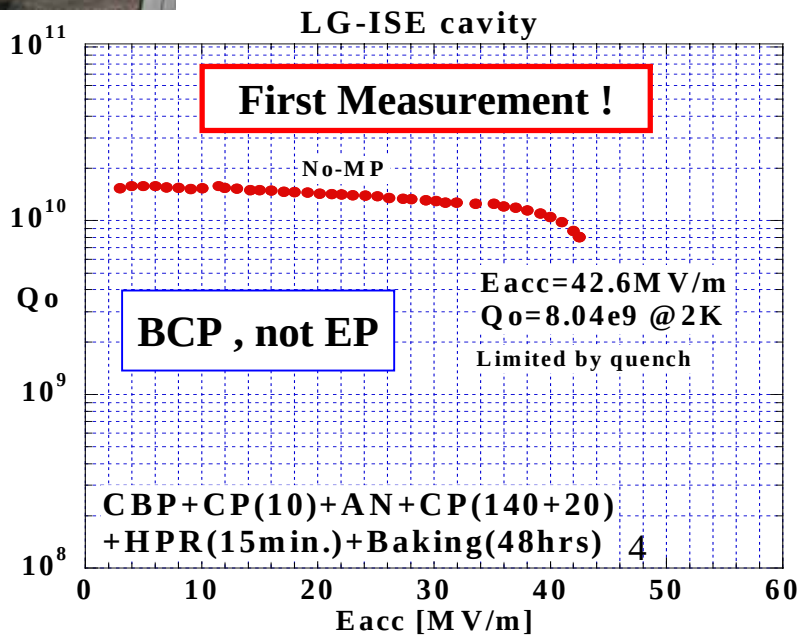


The surfaces have wire traces but no problem for cavity fabrication.

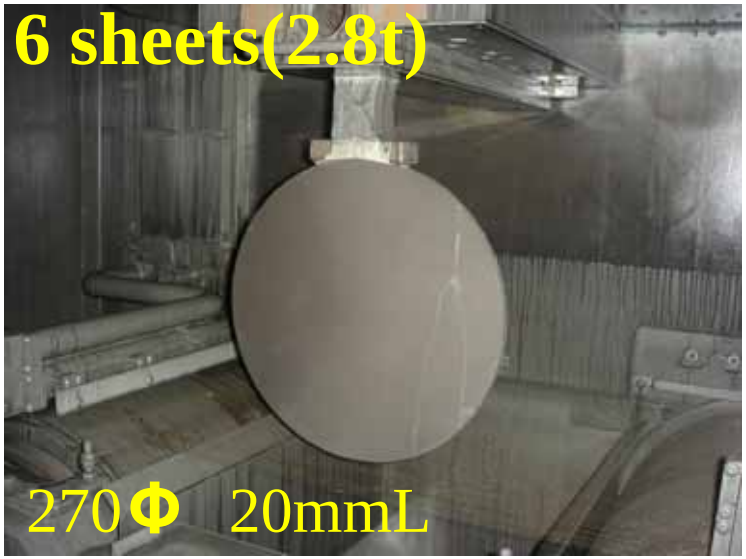
LL End single cell cavity

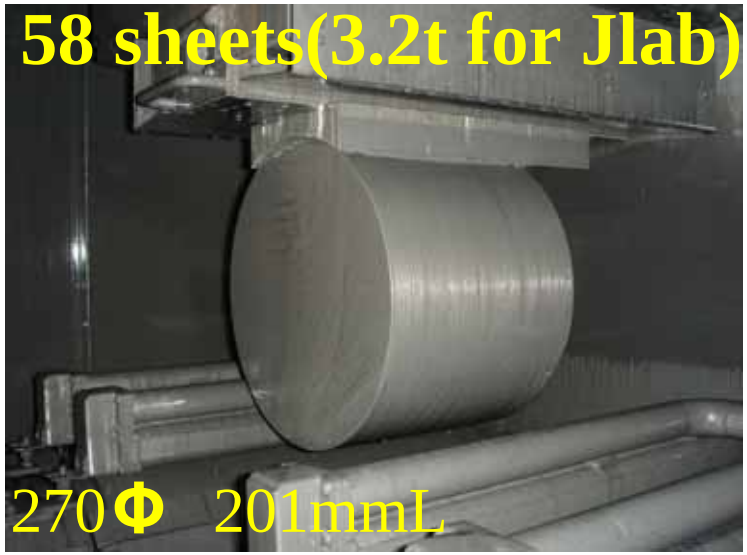
(End cell shape)

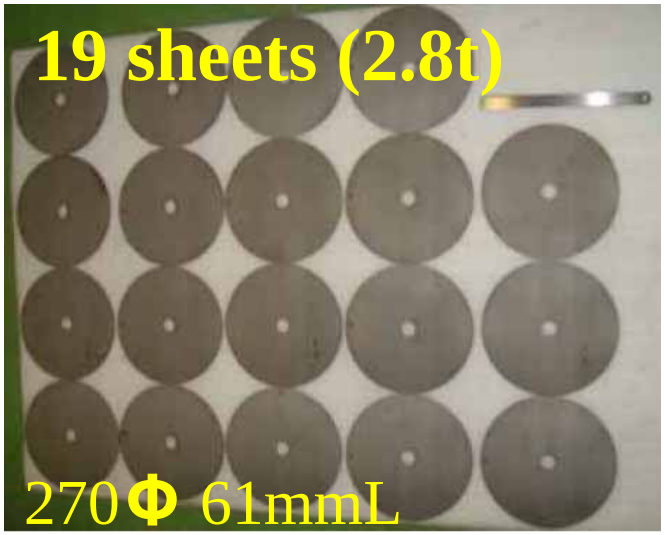
Directly formed from the sliced sheets.
No annealed the sheets.

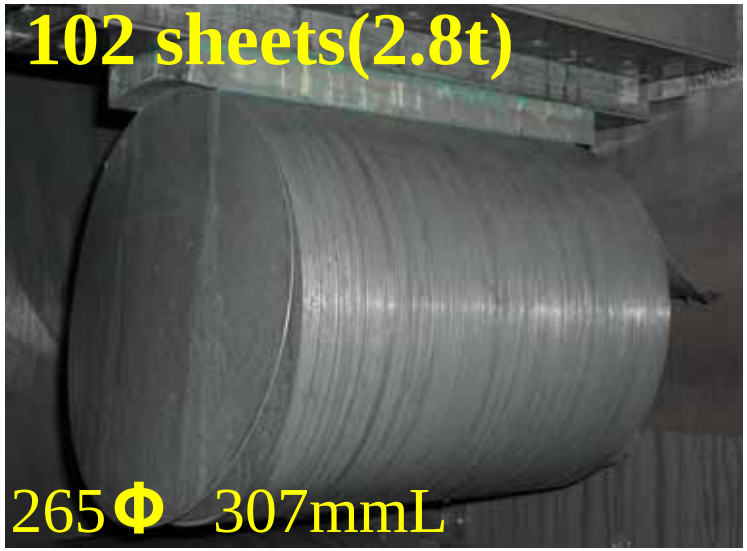


Step by step tests for more sheets production







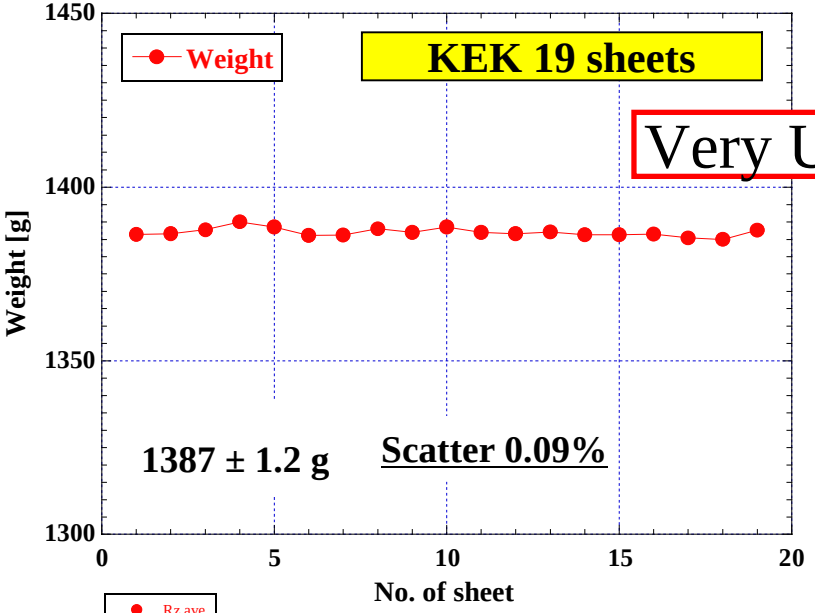


Sliced 102 Niobium Sheets for Cavity Fabrication

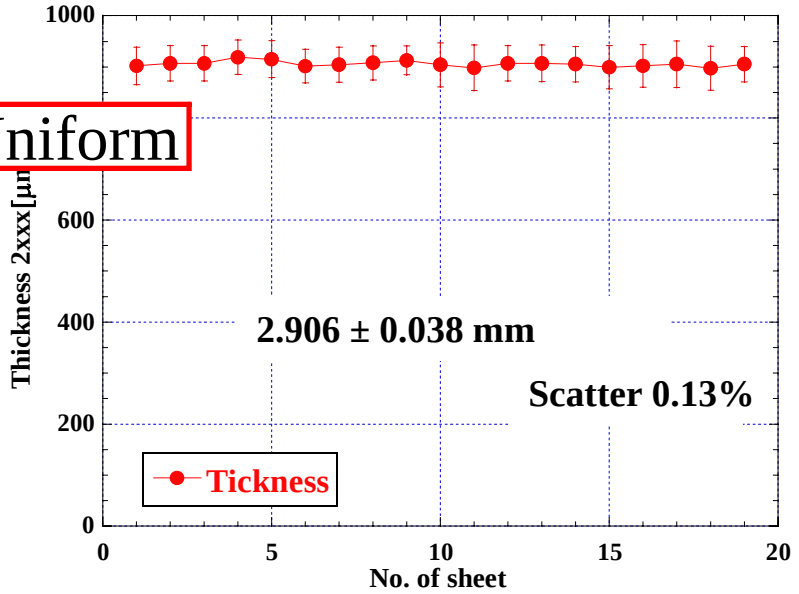
RRR reduction by this slicing is small, within the material variation.

480 → 430

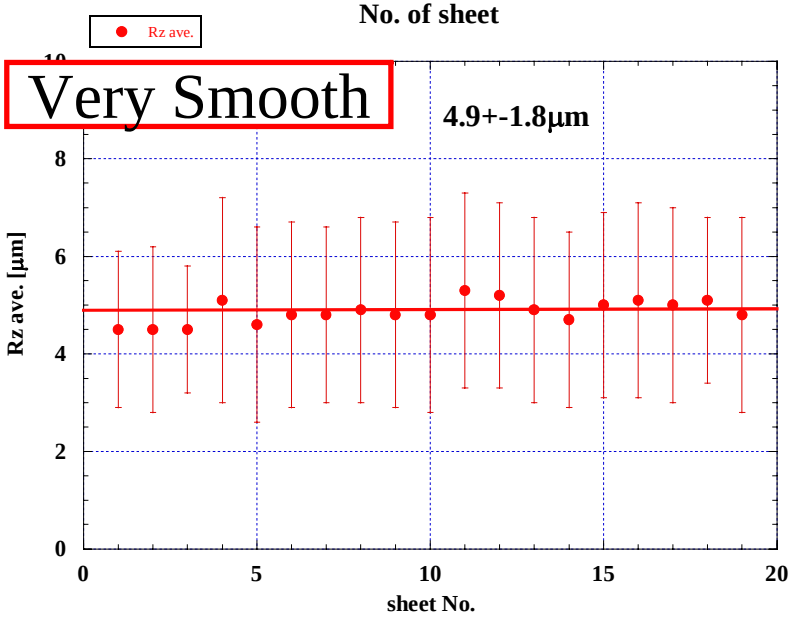
Feature of The Multi-Wire Slicing

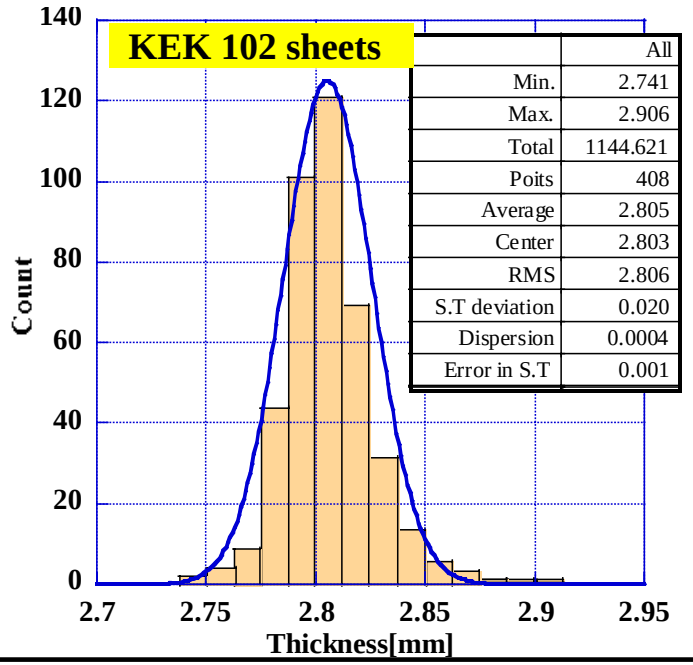


Very Uniform



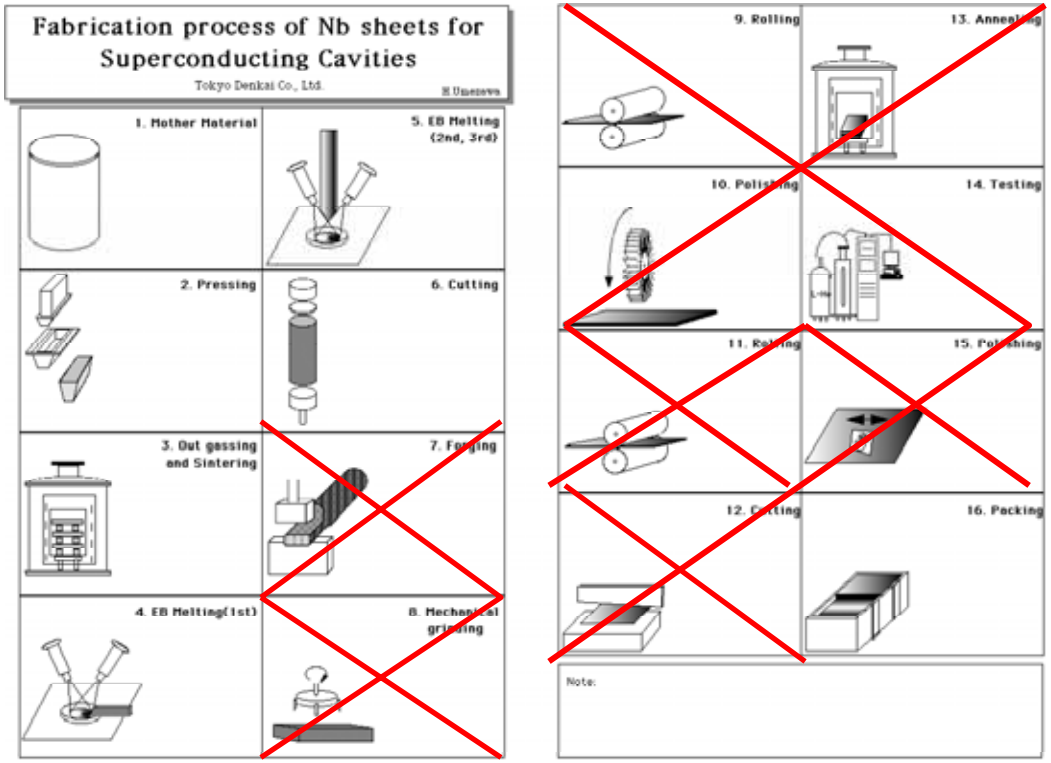
Very Smooth





Degradation of RRR by this slicing is 10% at max. but it is within the location variation of the Nb ingot.

Benefits of this slicing method



150sheets/3days,

if 450L ingot is ready.

Current

High Purity Nb Ingot → **Forging** → **Peeling** → **Rolling** → **Cutting** → **Grinding** → **Light CP** → **Annealing**

- Peeling: 15% waste
- Cutting: 27.4% waste
- Grinding: 2% waste
- Light CP: 0.7% waste

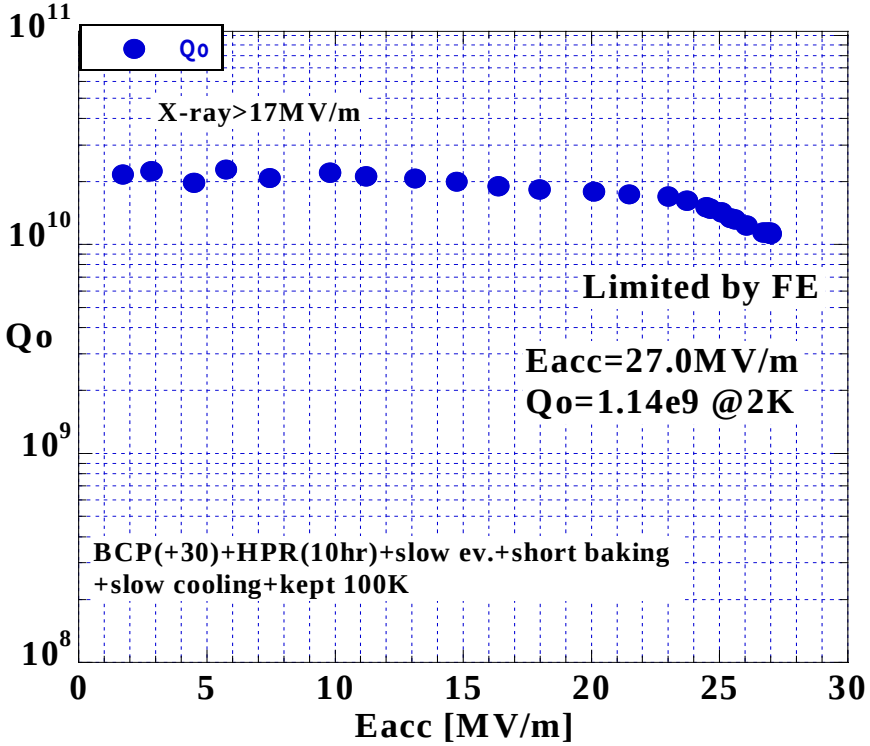
Multi-slicing

High Purity Nb Ingot → **Peeling** → **Slicing** → **Light CP**

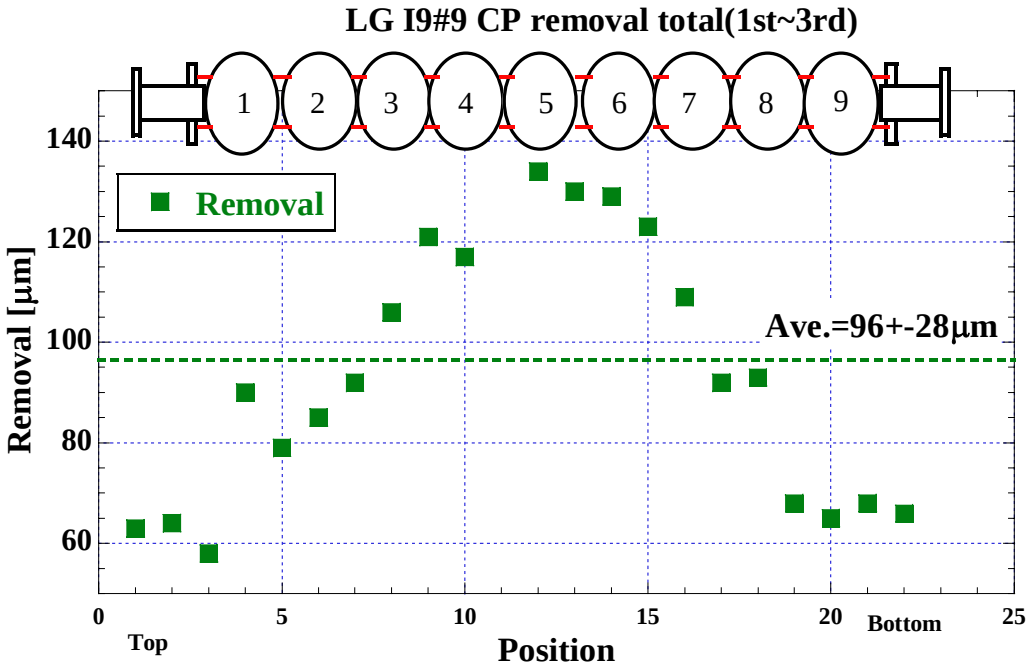
- Peeling: 8%
- Slicing: 6% waste
- Light CP: 0.7% waste

	Waste ratio [%]
Current	**45.1**
Slicing	**14.7**

Under Going LG 9-Cell Cavity Evaluation Test



Totally 96μm (in average) removed by BCP



Material removal distribution by the current BCP

KEK is developing a horizontal BCP system.

Summary

- **Silicon wafer multi-wire slicing technology has been successfully applied to Nb large grain sheet production. You can see the sheets in the exhibition Tokyo Denkai !!**
- **So far, we demonstrated 100 sheets production in a shorter than 50 hrs. It is very fast. We are sure 150 sheets in 50hrs. The commercial machine is limited by 150 sheets max (450L), so far. ILC is a scale 500 sheets per day, which can be realized only by those 3-4 machines.**
- **This slicing method can supply very uniform sheets within 20-40 μm thickness variation. The surface roughness is very smooth (about 5μm with Rz).**
- **This method can reduce the material wastes to 1/3 of the current production.**
- **A single cell cavity made of the sliced Nb sheets was successfully tested. 42 MV/m was achieved in the first measurement by the combination of L.G material + LL shape + BCP.**
- **Testing of a LL 9-cell cavity is under way in KEK. The gradient is 27MV/m so far.**
- **Tokyo Denkai will install this machine by the end of 2009 and will start slicing soon. They have applied the both patents on JPN domestic and International.**