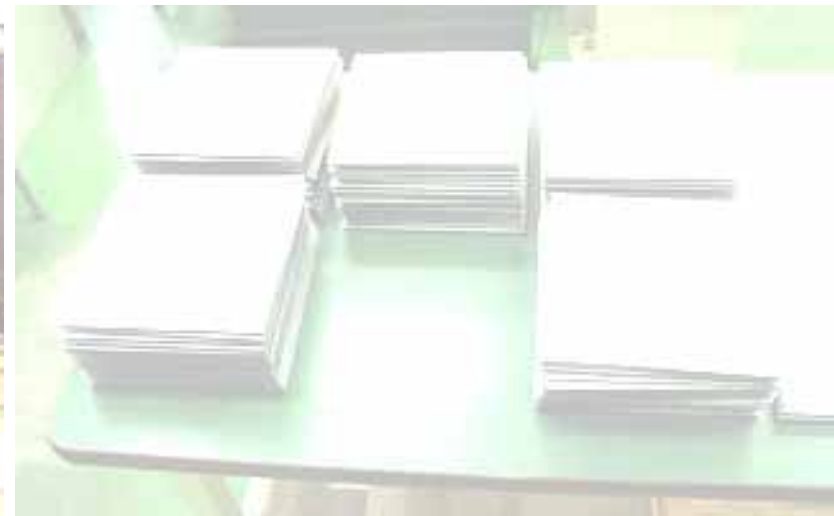


2. Niobium Material for SRF Cavities

2.1 Niobium Mien

2.2 High Purity Niobium Industrial Production



2.1 Niobium Miens



Niobium mine: Carbonatite

Big three mines in the world

Brazil : Araxá (アラシャ)

Catalão (カタラウン)

Canada : St. Honore

(サン・オノレ)

図1 世界のニオブ埋蔵地 (■)
とニオブ製品を生産する主要な
鉱山 (★)

Niobium is 33rd abundant metal element in the earth.

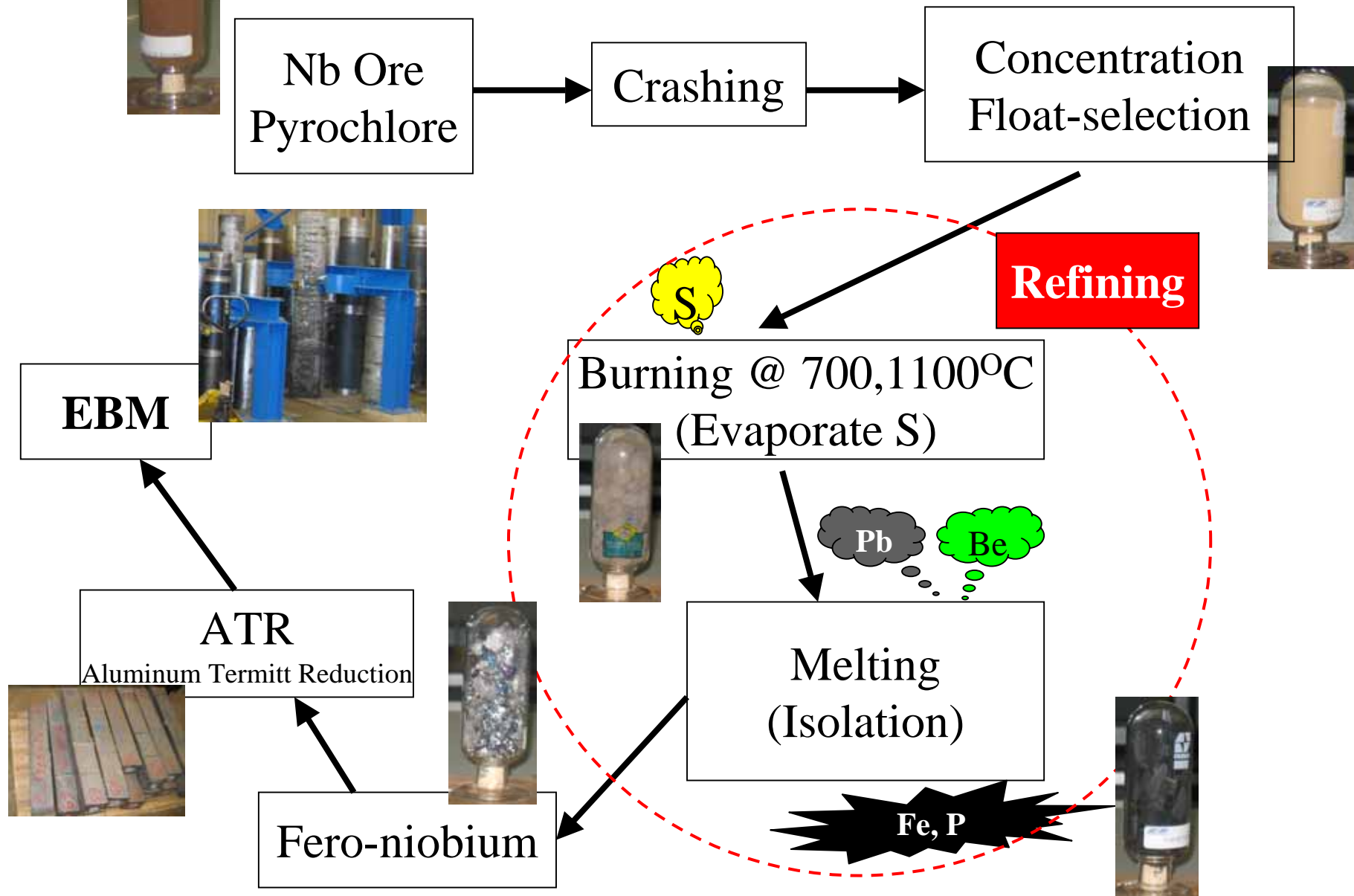
Niobium Mien



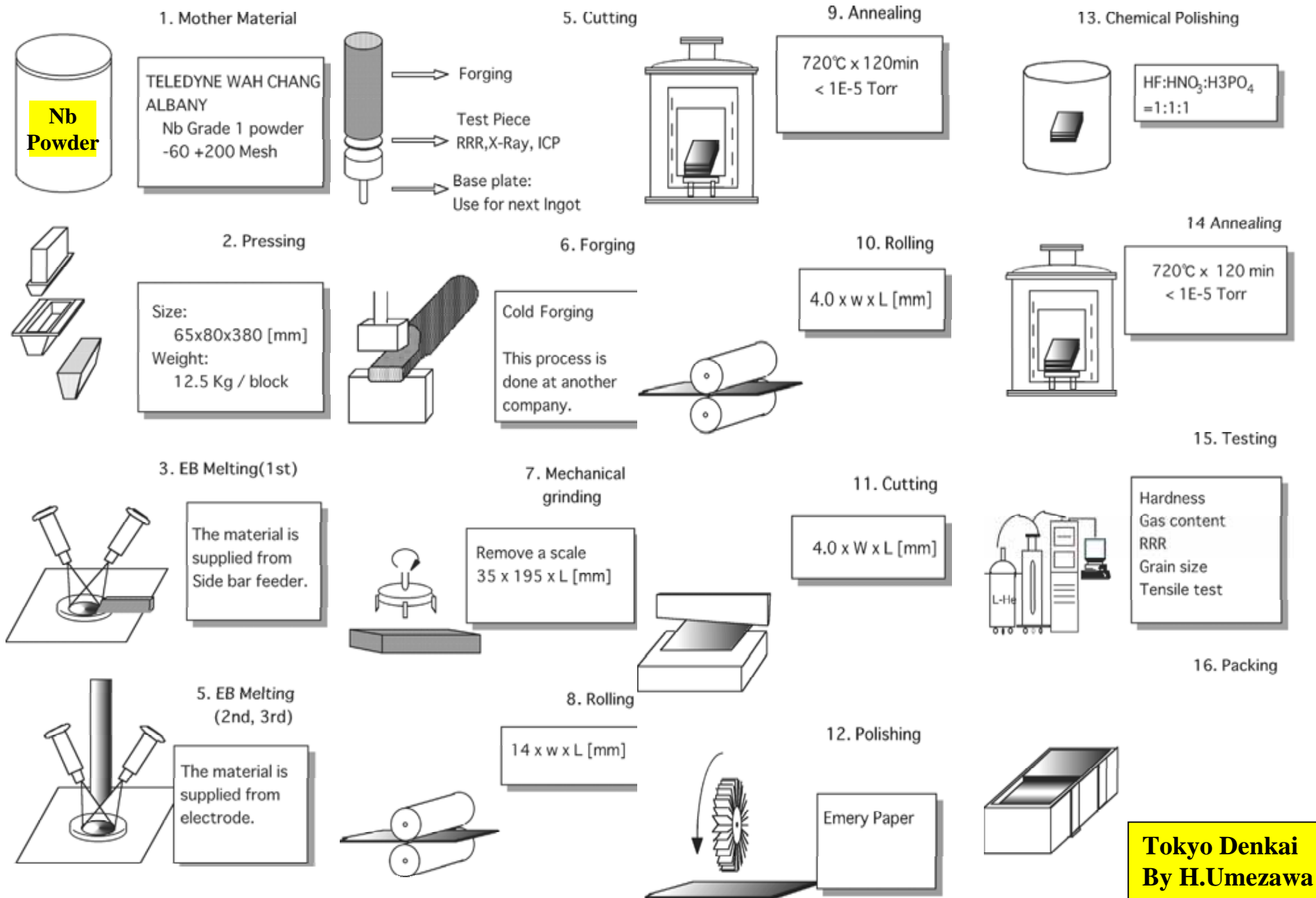
Brazil, CBMM, Araxia Mine

Process of Niobium Refining

CBMM



2.2 High Purity Nb Industrial Production

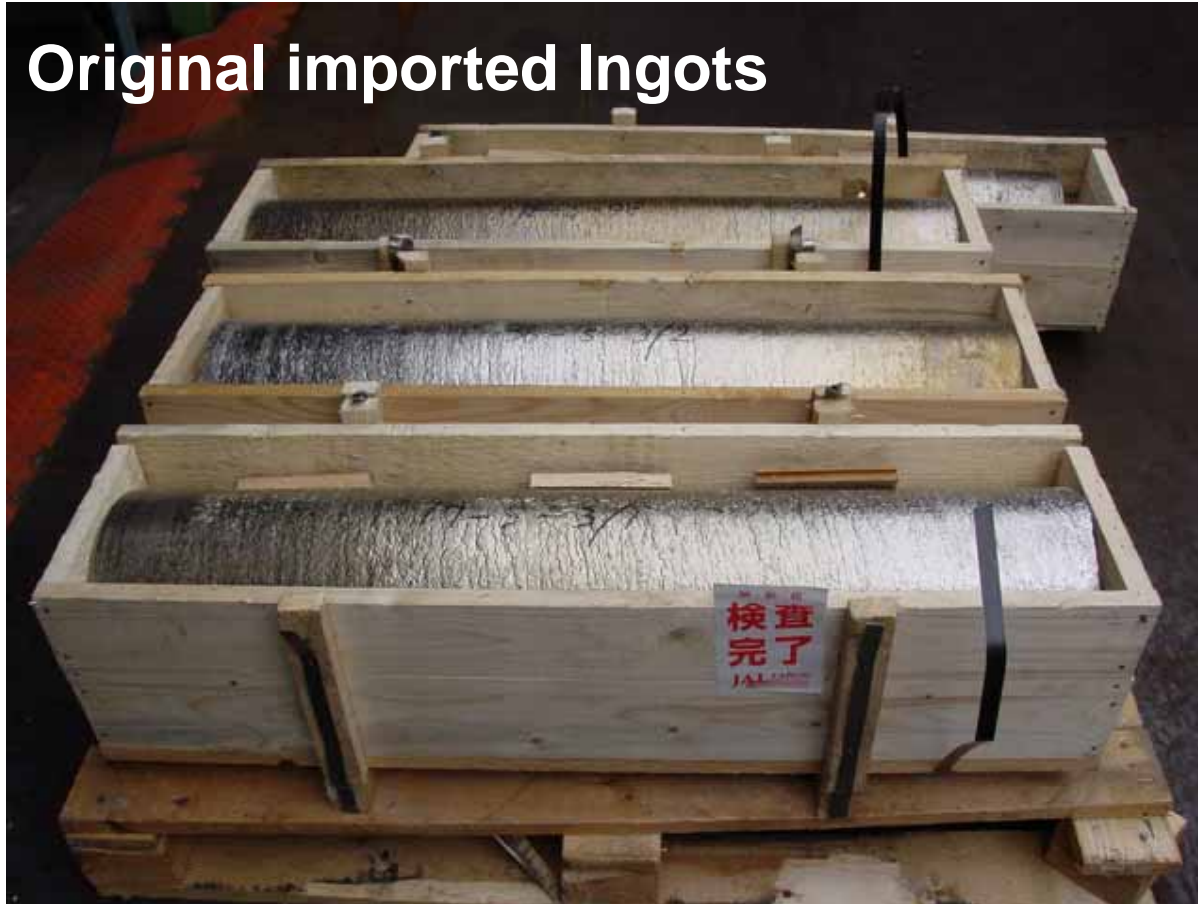


Tokyo Denkai
By H.Umezawa

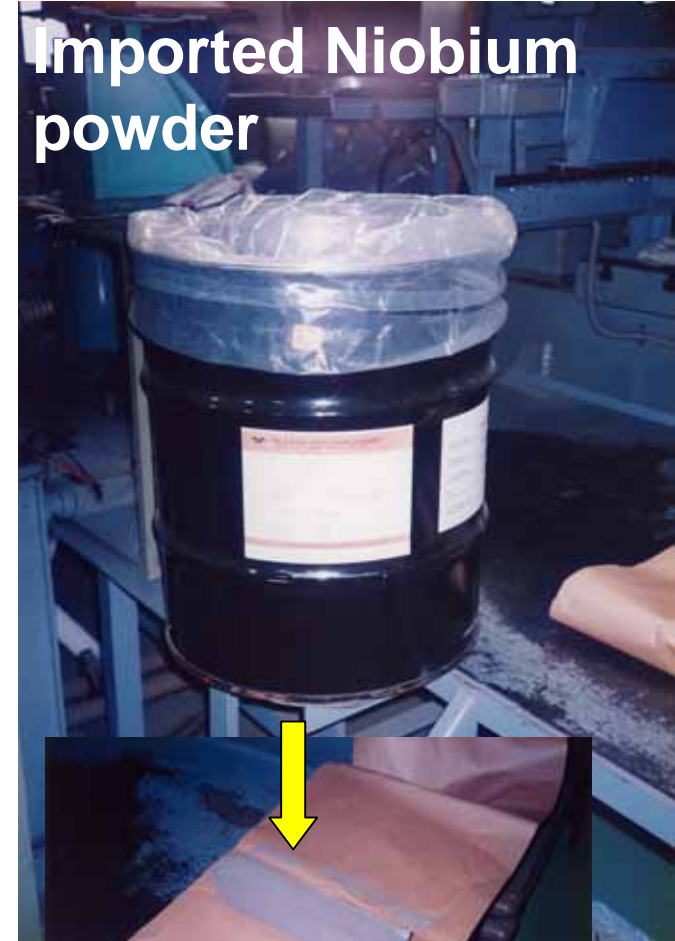
Original material for high pure niobium

Tokyo Denkai

Original imported Ingots



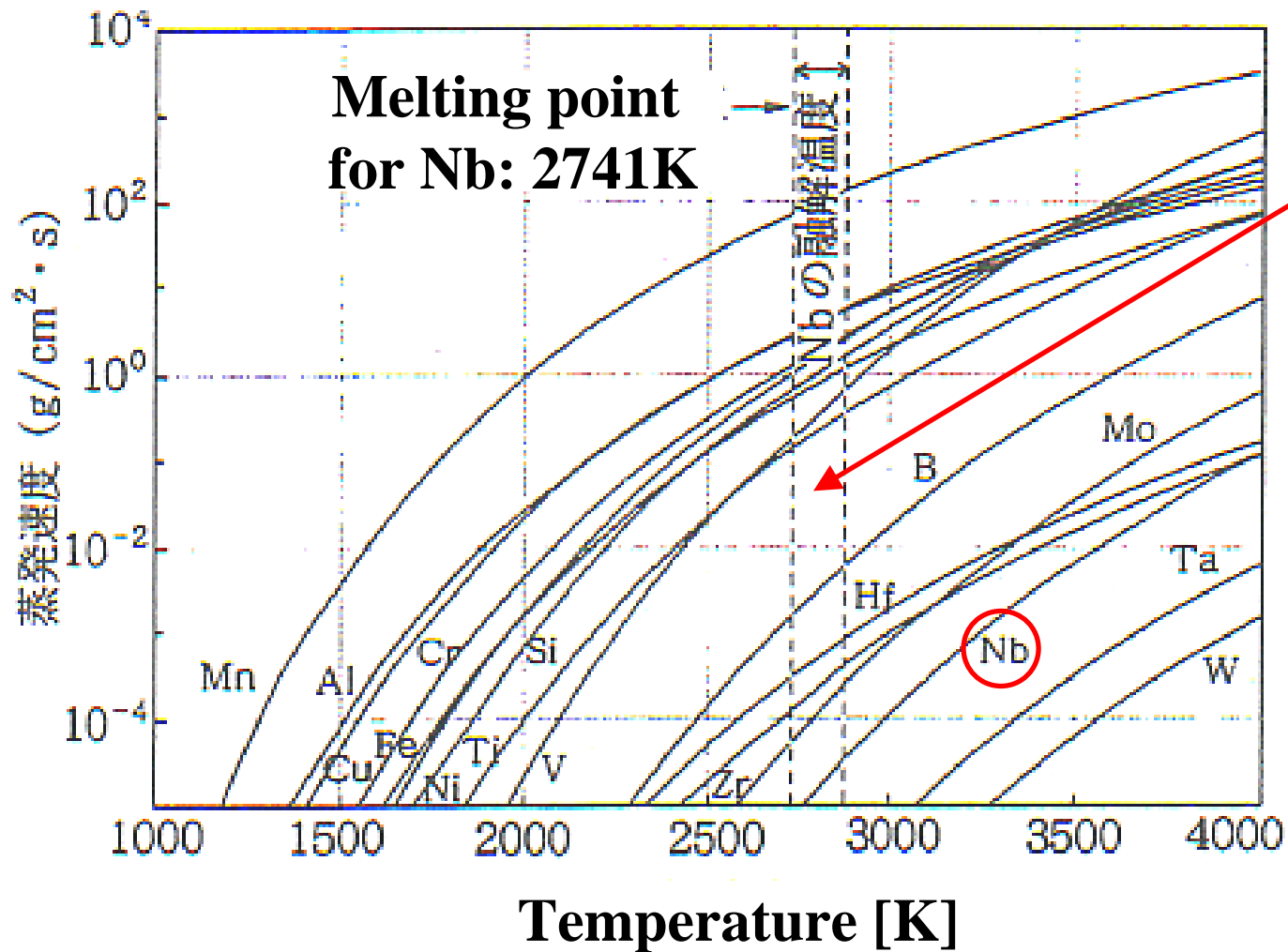
Imported Niobium powder



Pressed powder

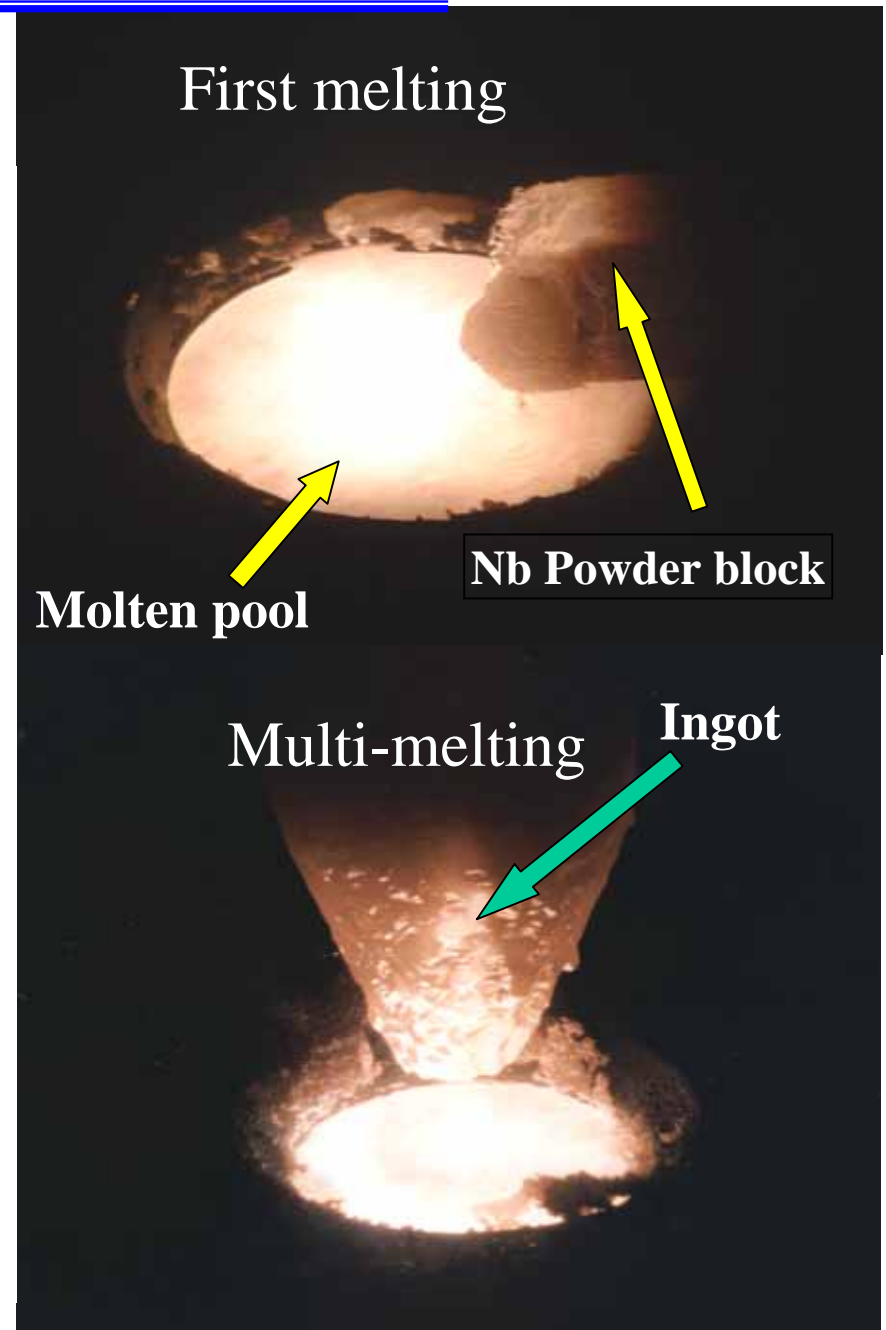
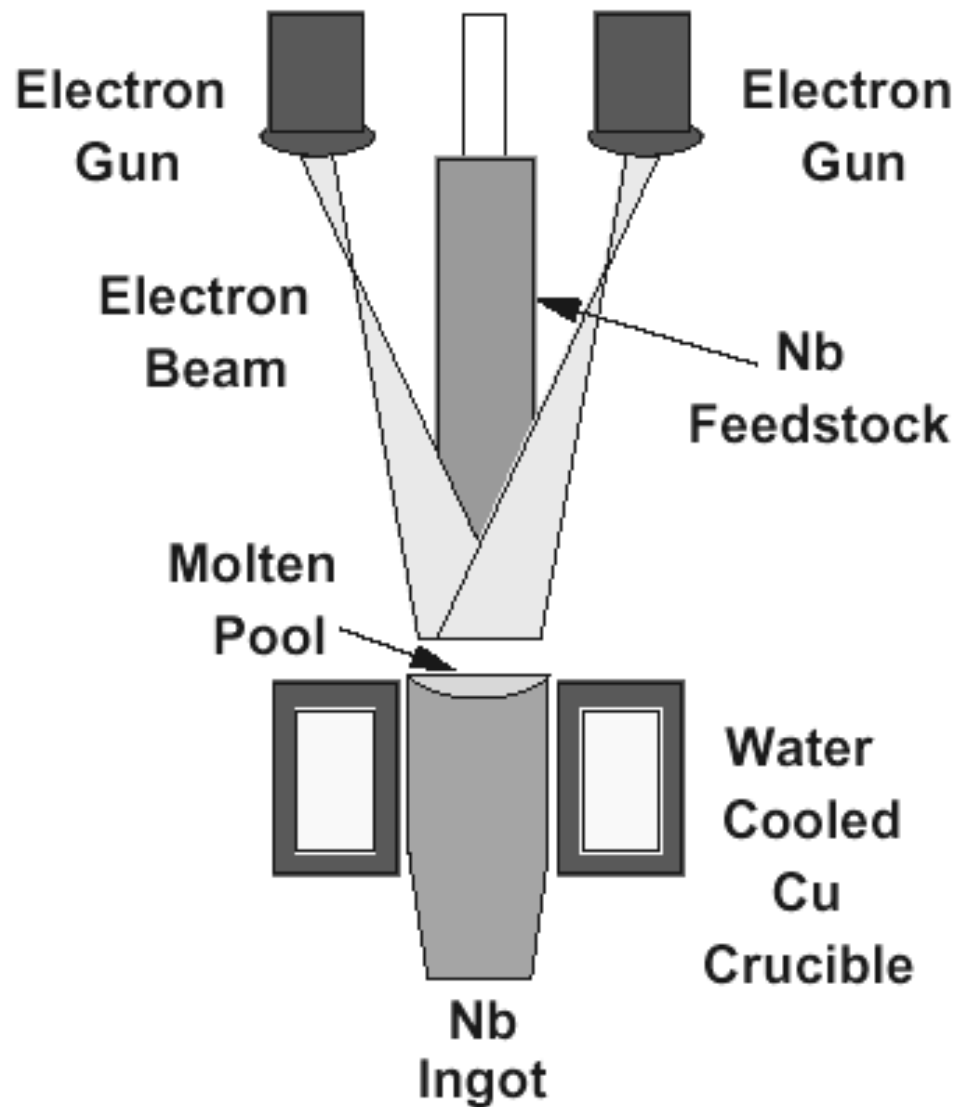


Vapor Presser for various metals



Evaporated easily
except for Nb, W, Ta

Electron Beam Melting



EBM furnace and Nb Ingots

400kw EBM furnace



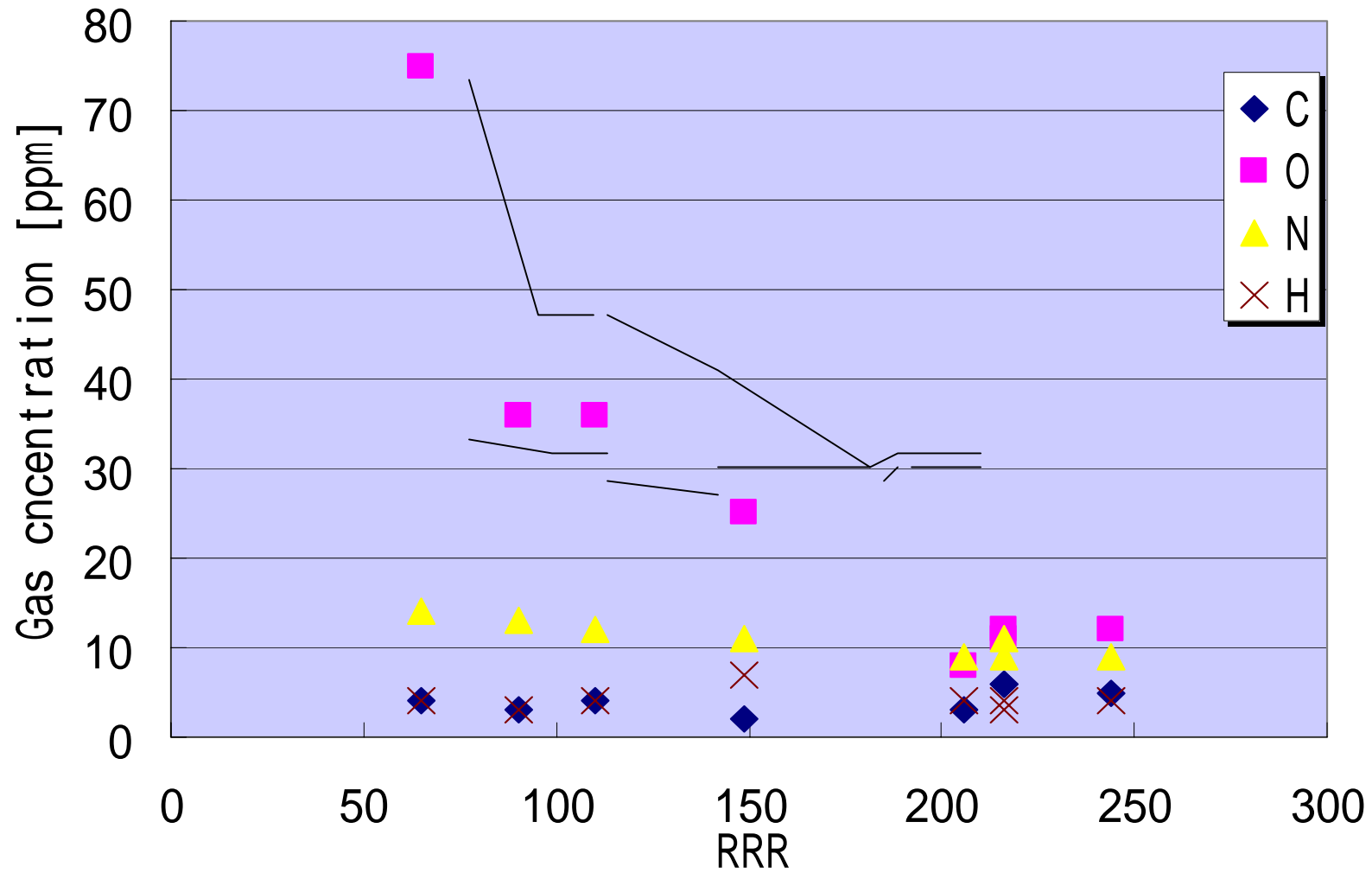
Tokyo Denkai

Nb Ingots after multi-melted

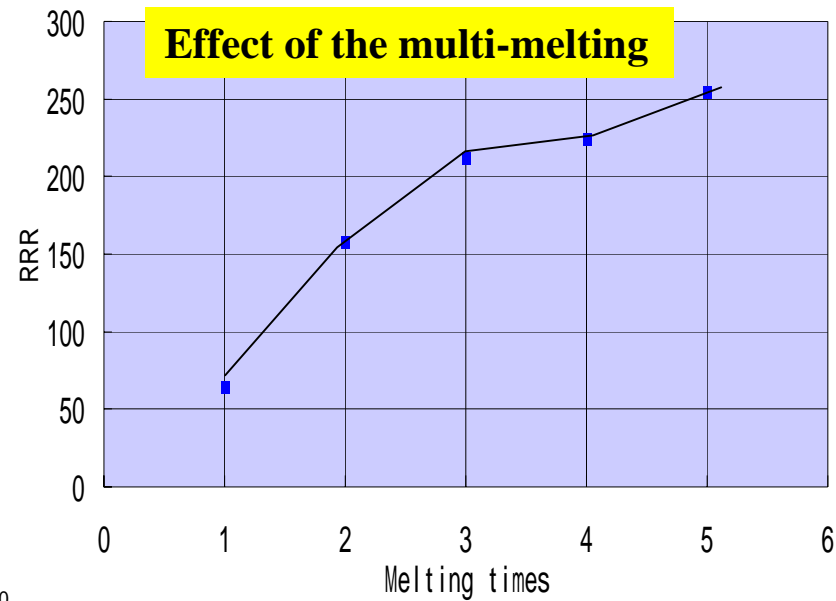
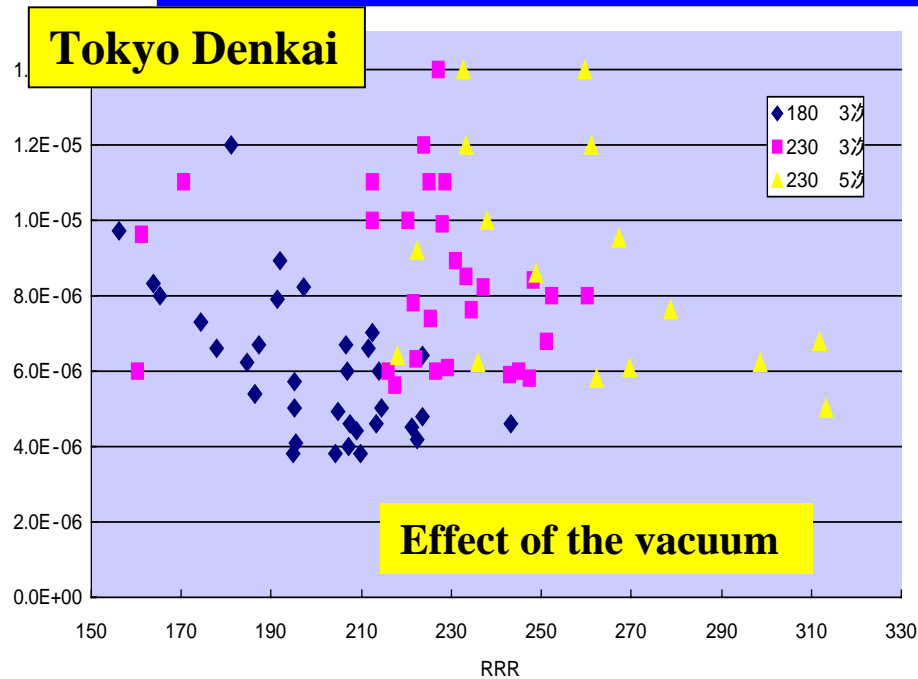


450 kg

Impurities

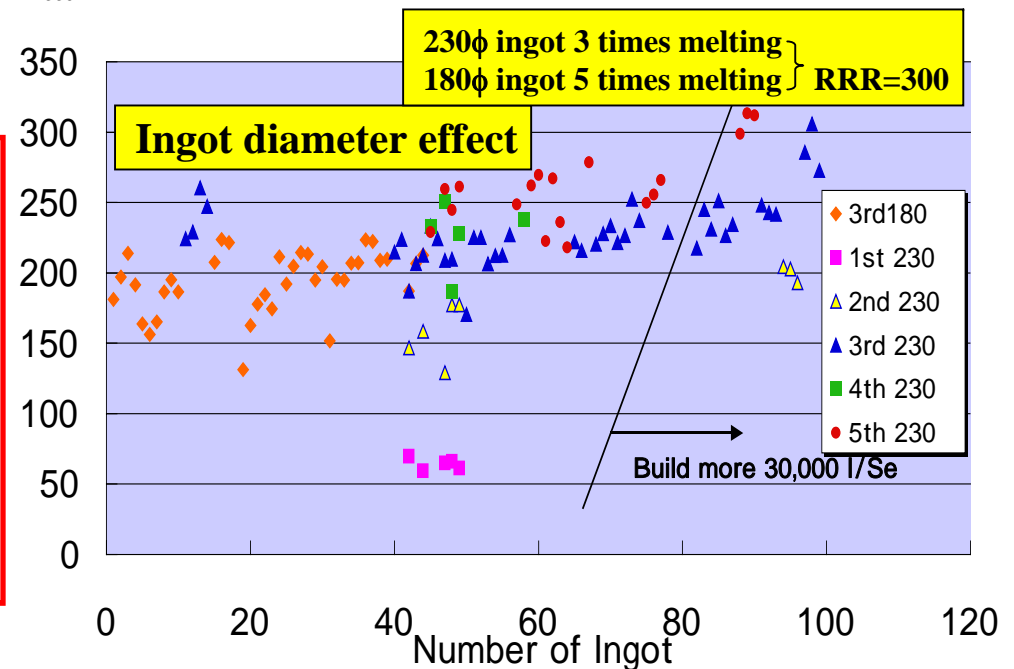


Keys for High purity Nb Ingot production



Three keys:

- 1) High Vacuum,
- 2) Multi-melting,
- 3) Large molten pool surface
(Large Ingot diameter)

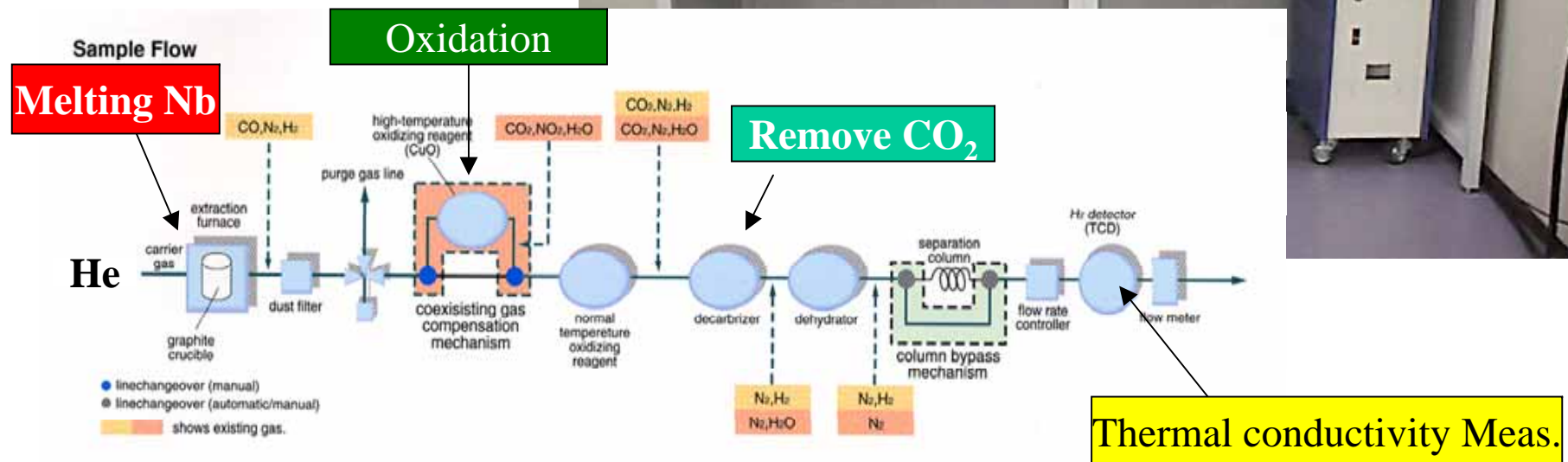


Gas analysis in niobium

Tokyo Denkai



Case of N



Gas analysis (Hydrogen, Oxygen, Nitrogen) : HORIBA

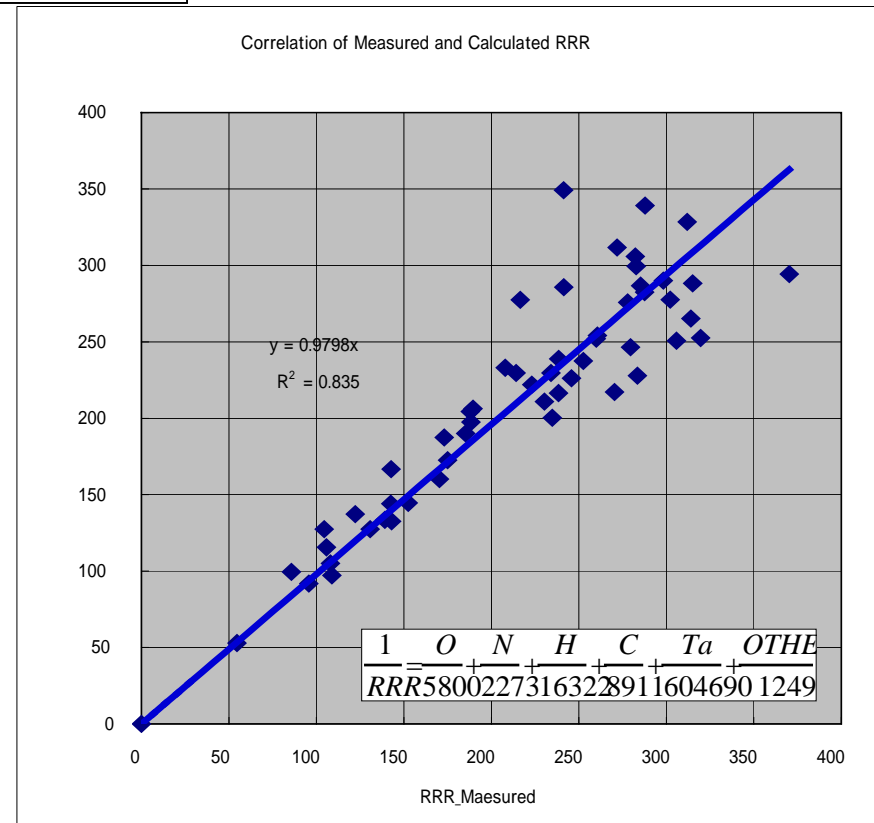
Regression Analysis Result

K.K.Schulze: J. Metals, 33(1981), 33-41

$$\frac{1}{RRR} = \frac{O}{5000} + \frac{N}{3900} + \frac{H}{1550} + \frac{C}{4100} + \frac{Ta}{550000} + \dots$$

Umezawa's (Tokyo Denkai) result.

$$\frac{1}{RRR} = \frac{O}{5800} + \frac{N}{2273} + \frac{H}{16322} + \frac{C}{8911} + \frac{Ta}{604690} + \frac{1}{1249}$$



Rolling

Tokyo Denkai

Intermediate rolling



Cleanroom

Final rolling



Careful control against dust

Vacuum annealing system

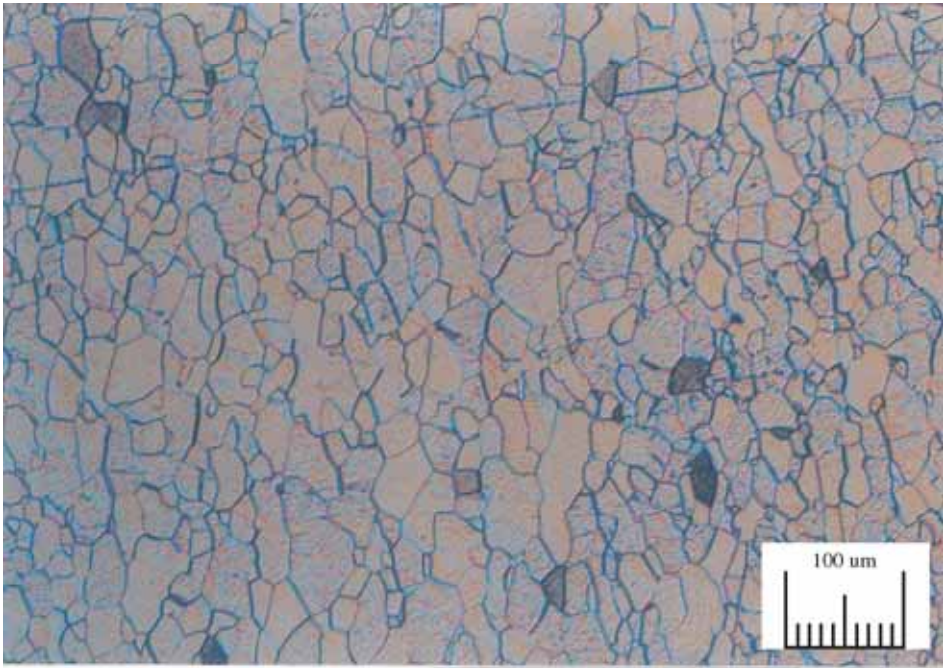


Tokyo Denkai
1400°C Max,
 $\sim 1 \times 10^{-6}$ Torr
Effective working zone
1000 ϕ x 1800L
Ta heater

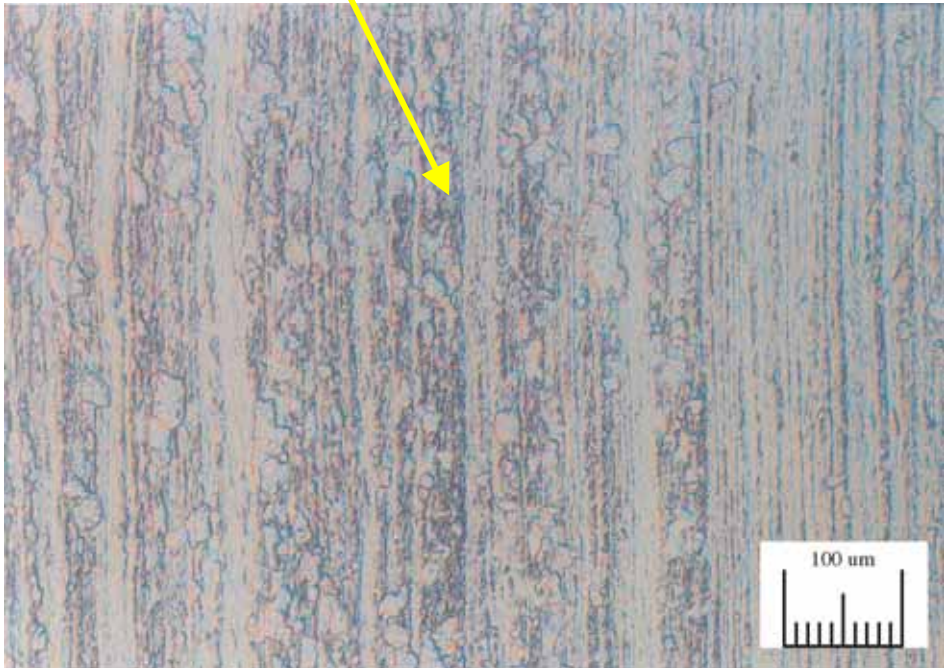


Metallurgy of Nb

Remained roll rolled structure



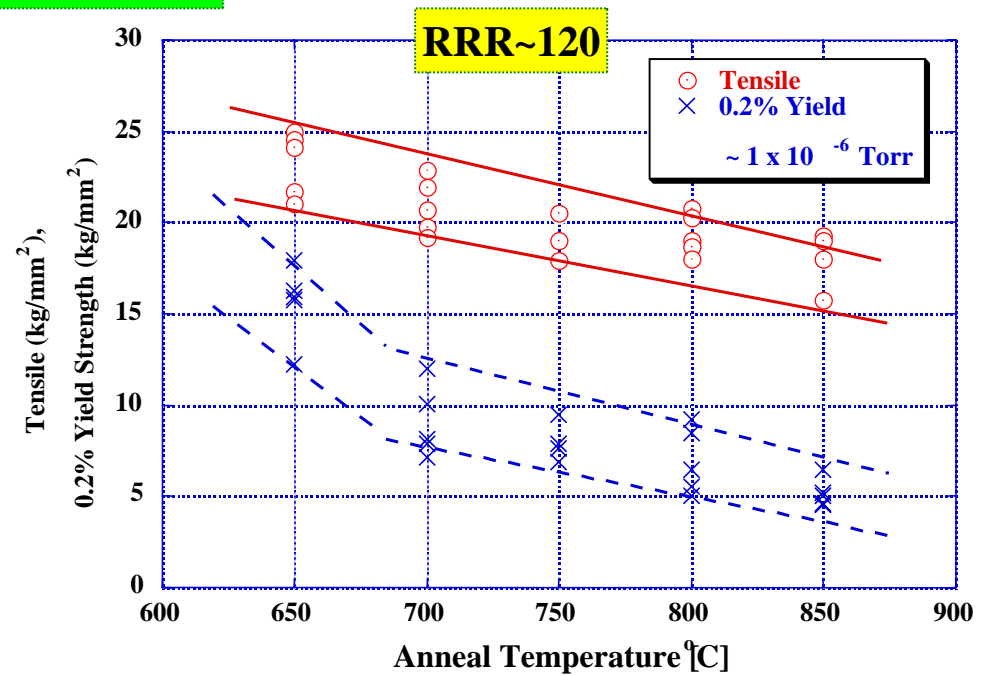
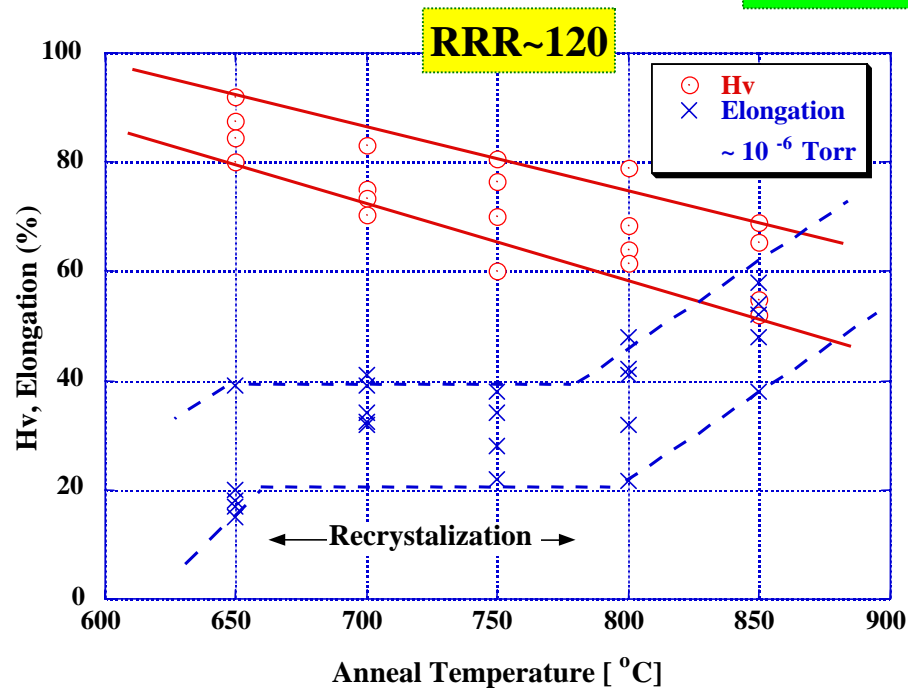
Well annealed



None annealed

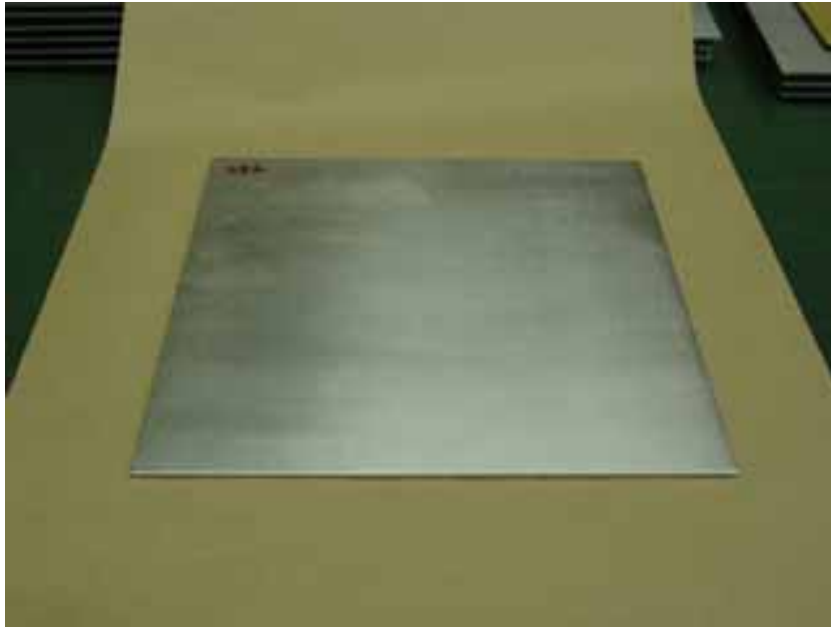
Annealing Temp. and Mechanical Properties

TRISTAN



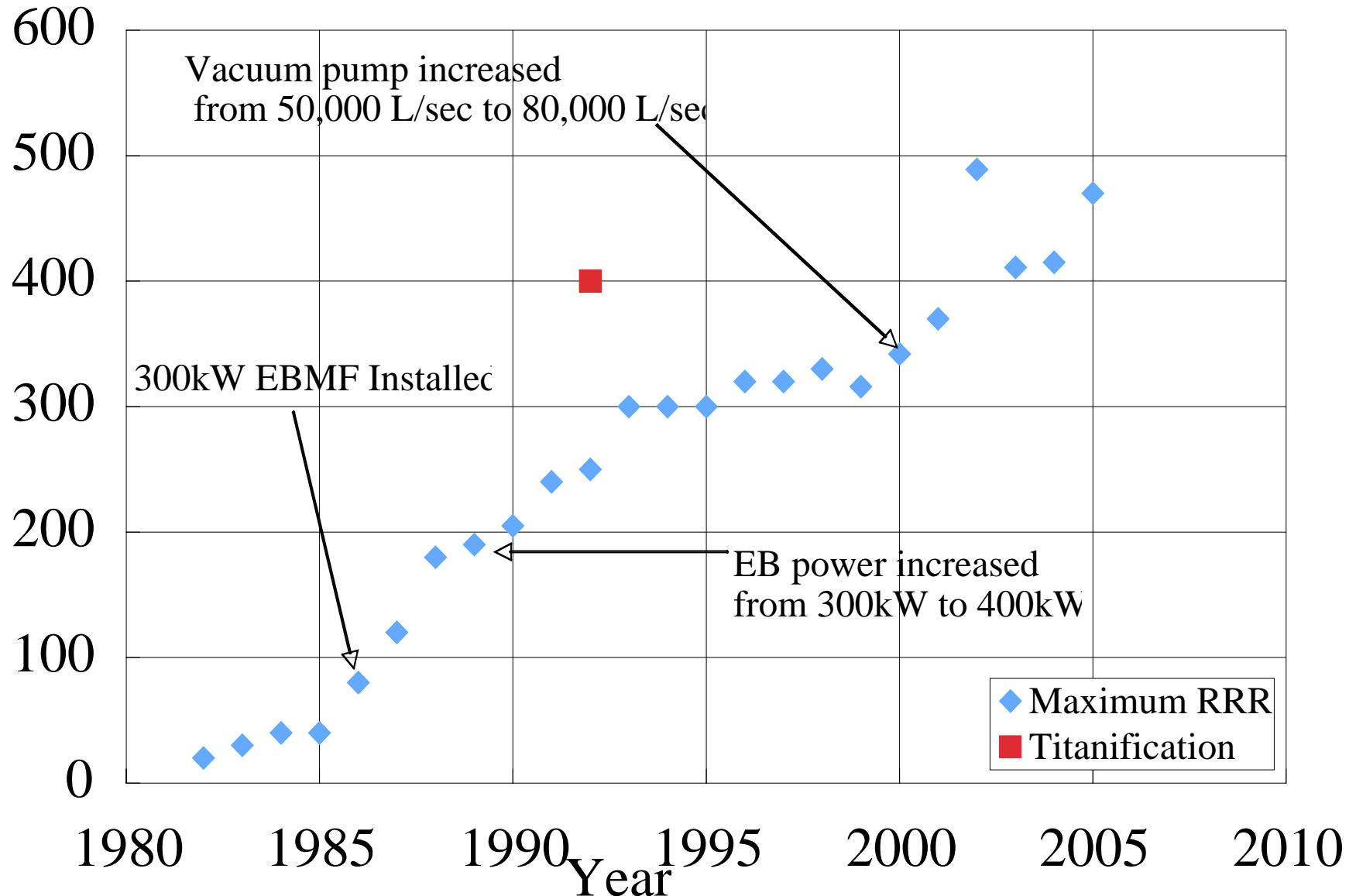
Re-crystallization Temperature : 680 ~ 780°C
Vacuum Pressure : $\sim 10^{-6}$ Torr

High Pure Niobium Sheets



Tokyo Denkai

Improvement of RRR at Tokyo Denkai



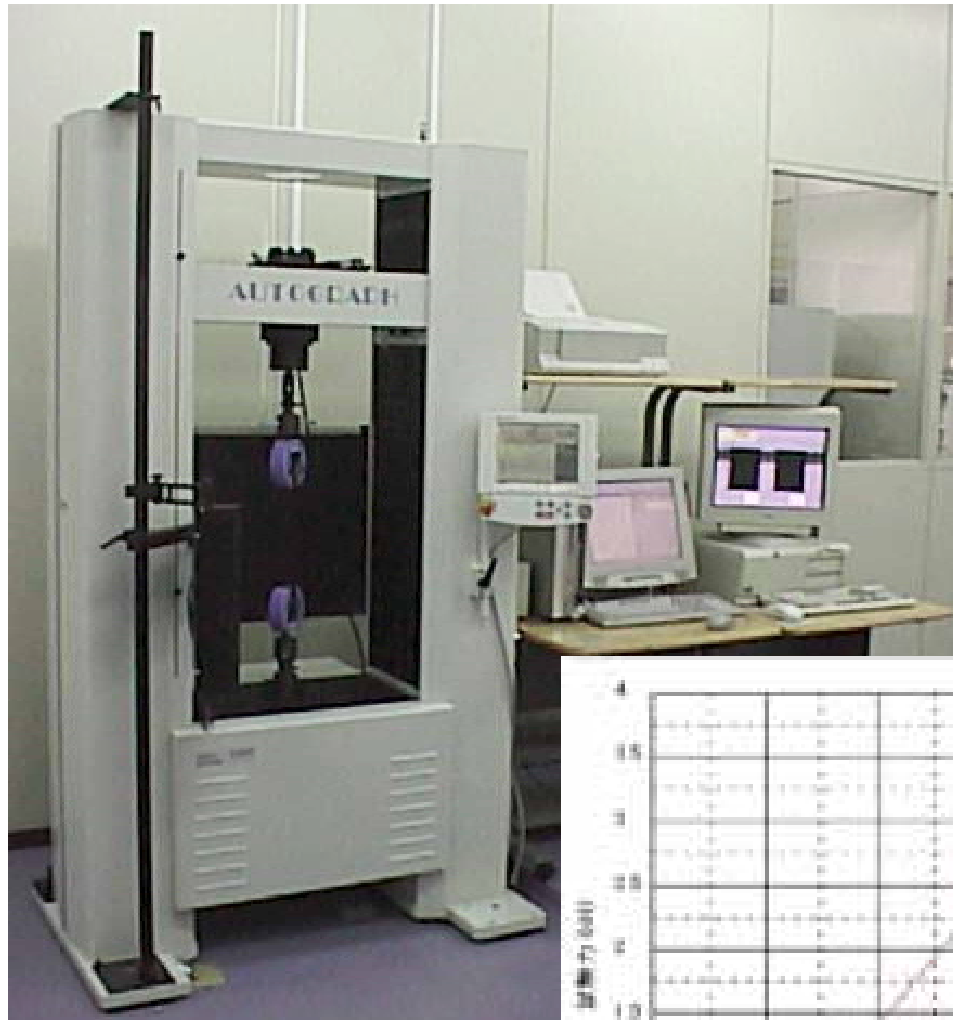
RRR measurement



Tokyo Denkai



Tensile Test



Tokyo Denkai

試験速度1: 0.5 mm/min 試験速度2: 2.5 mm/min
 切替点1: 1 mm 切替点2: 4 N/2mm

製品: 平板

単位	厚さ	幅	標尺距離
mm	3.00	6.00	25.00

名前	引張強さ	最大引張強さ	破断点位置	弾性率 Standard	破断点ひずみ
平均値	0.2 K			0.111	
単位	N/mm ²	N/mm ²	mm	N/mm ²	%
1-1	50508	144129	136704	201512	485761

名前	最大引張力
単位	kN
1-1	80824

