J-PARC高強度・高分解能飛行時間型中性子回折法を用いて目指す構造材料研究

Studies on structural materials using the J-PARC high-strength, high-resolution time-of-flight neutron diffraction method

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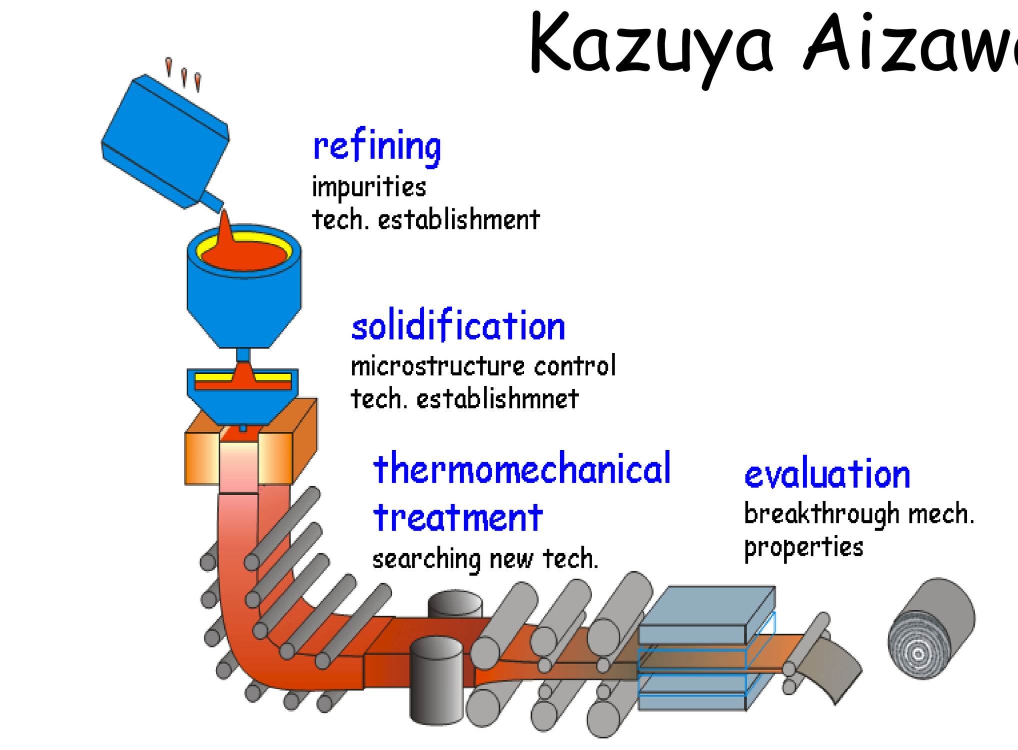
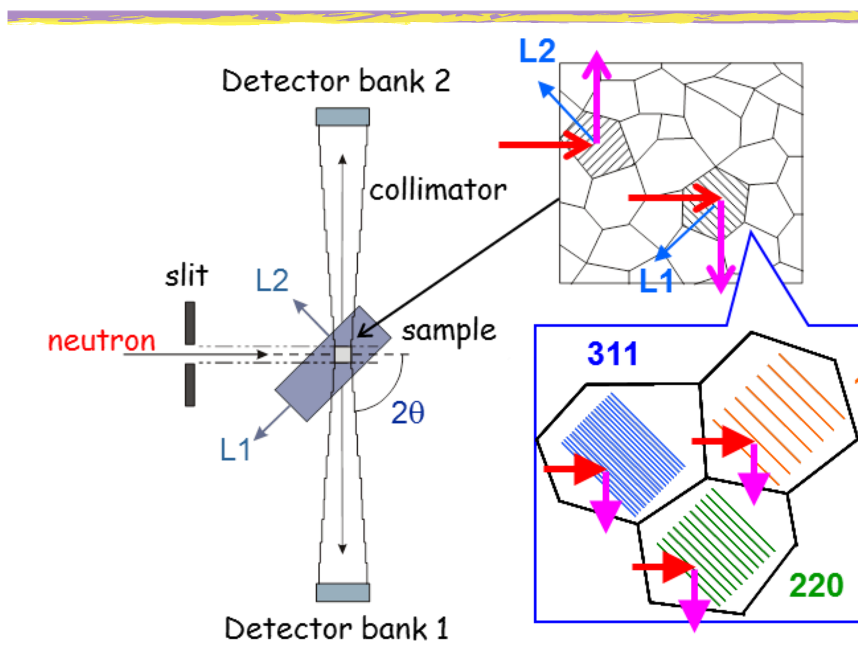
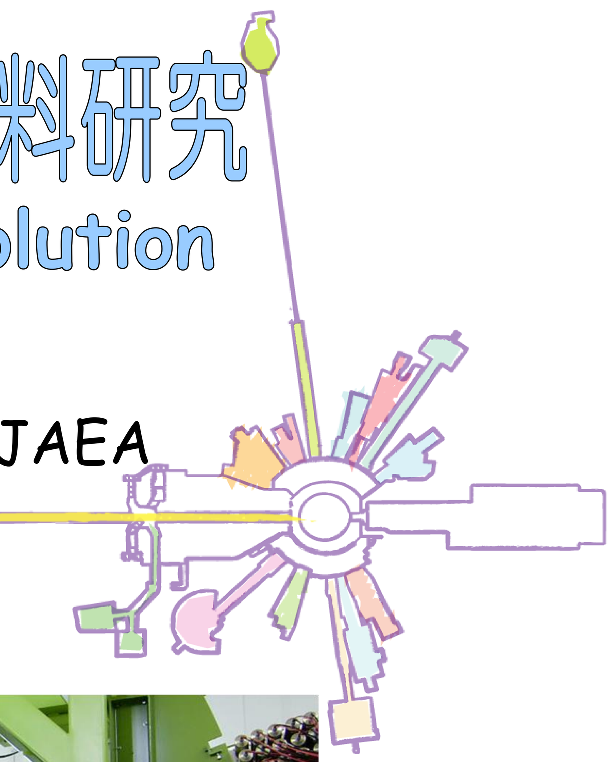


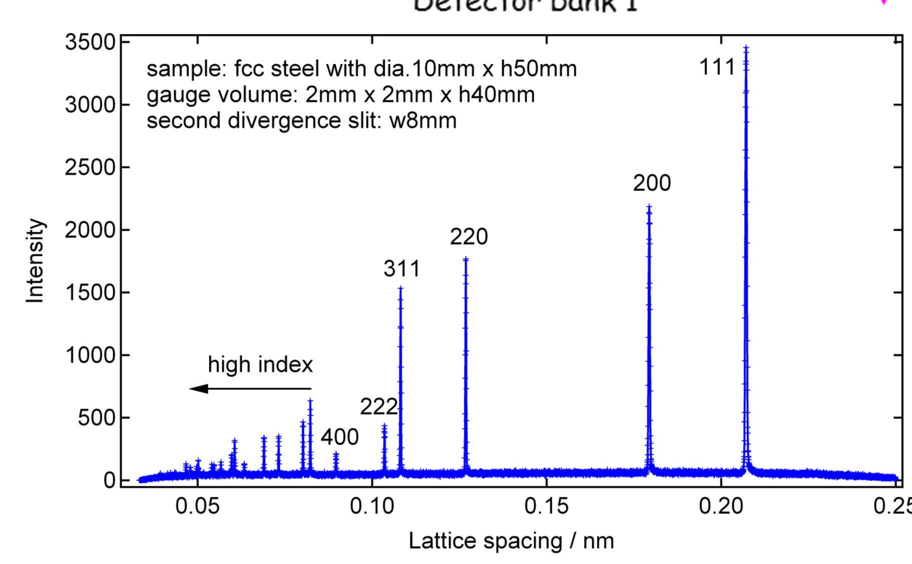
in situ observation of microstructure as average bulk data

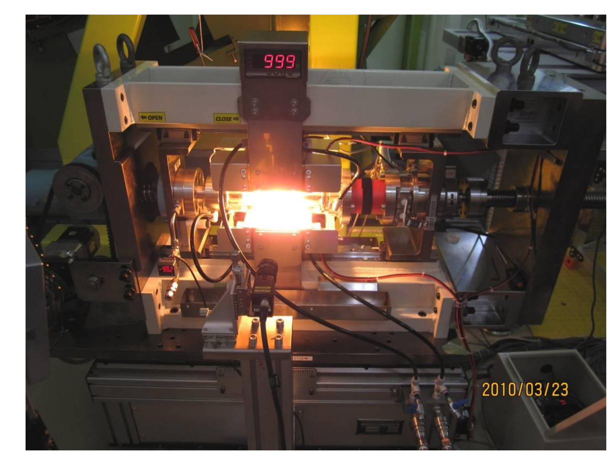




information needed :

- -> macroscopic strain
- -> phase transformation
- -> texture
- -> non-uniform strain (dislocation, etc)
- -> crystallite size (grain boundaries, twinning, etc)



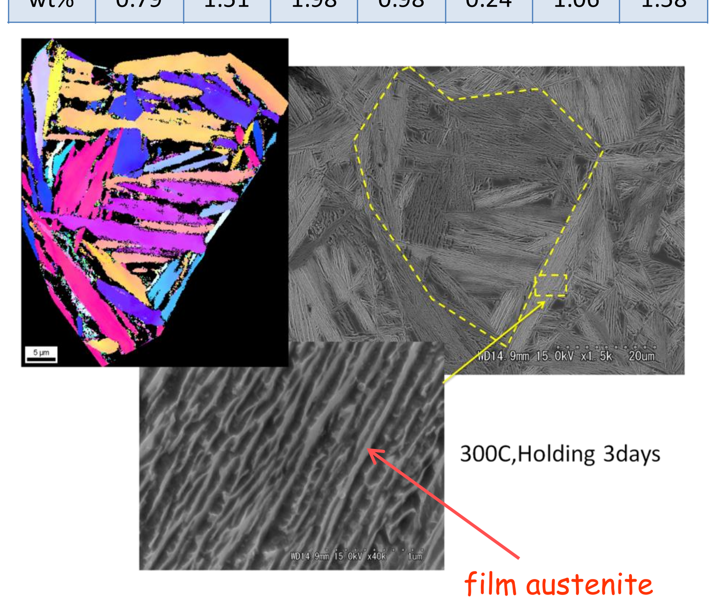


- -> high intensity high resolution engineering diffractometer : **TAKUMI**
- -> measurement with wide d-range (& multi scattering vector) : **TOF instrument with multi banks**
- -> flexible data manipulation : **event data recording method**
- -> sample environments : e.g. **high temperature loading machine**

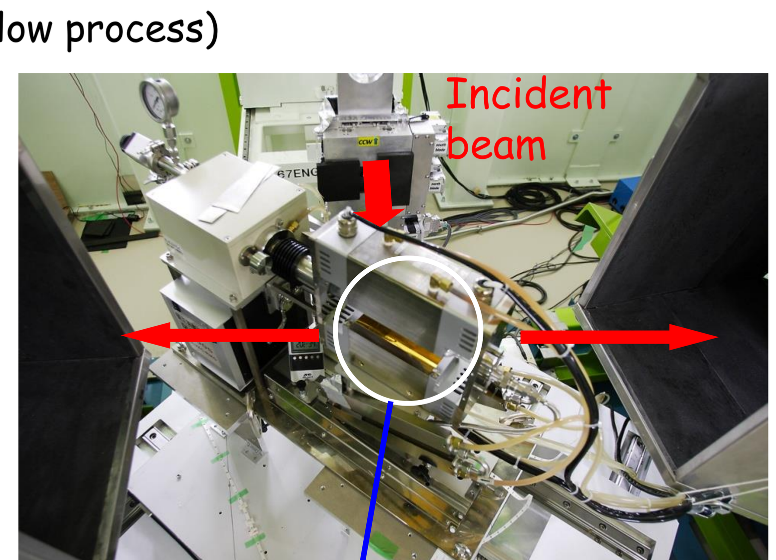
Nanobainitic isothermal process (-> slow process)

TAKUMI @ 20 kW (2009)

Element	C	Si	Mn	Cr	Mo	Al	Co
wt%	0.79	1.51	1.98	0.98	0.24	1.06	1.58

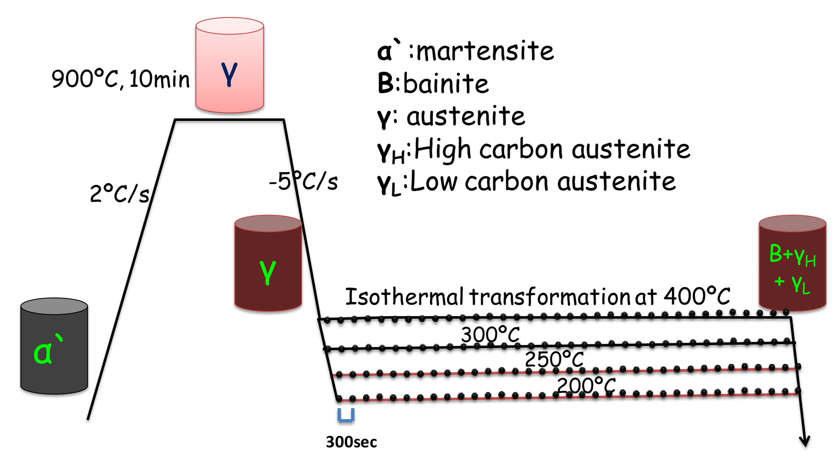


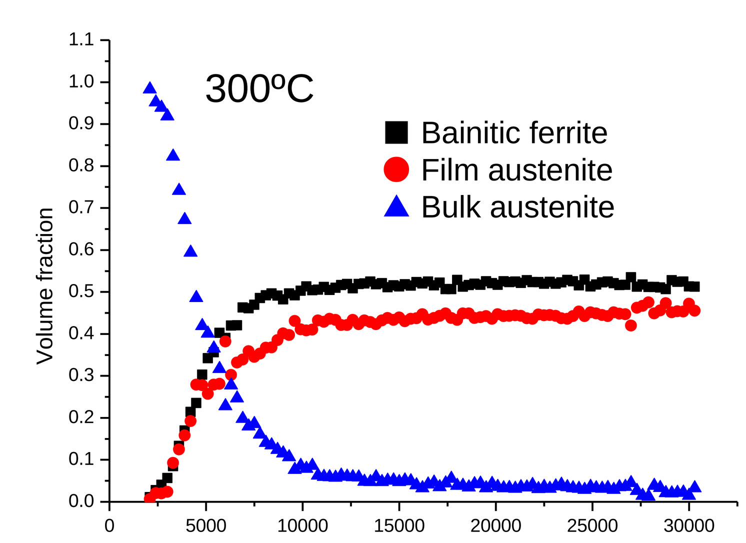
Bainitic process -> dilatation
process starting, ending
volume fraction data ?
In situ diffraction
microstructural evolution
process starting, ending

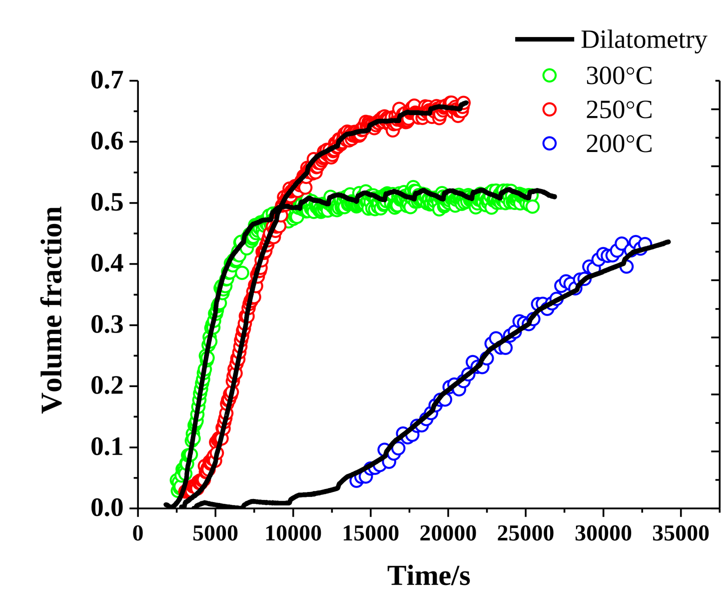


vacuum (or inert gas)

Thermodilatometry







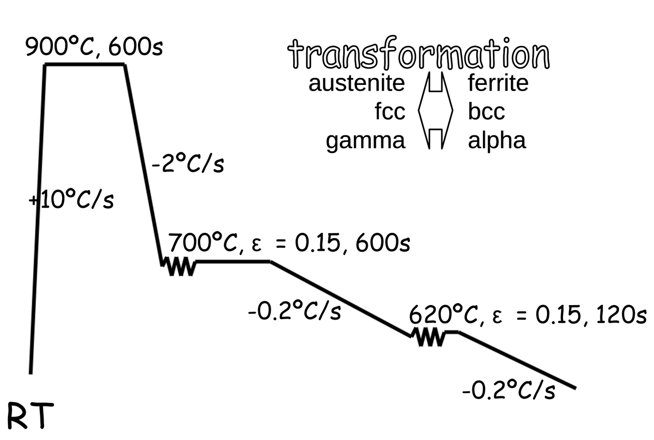
Bainitic transformation starts slowly depending on the isothermal temperature (diffusion of carbon)

Bulk dilatation is relevant to volume fraction of bainitic ferrite

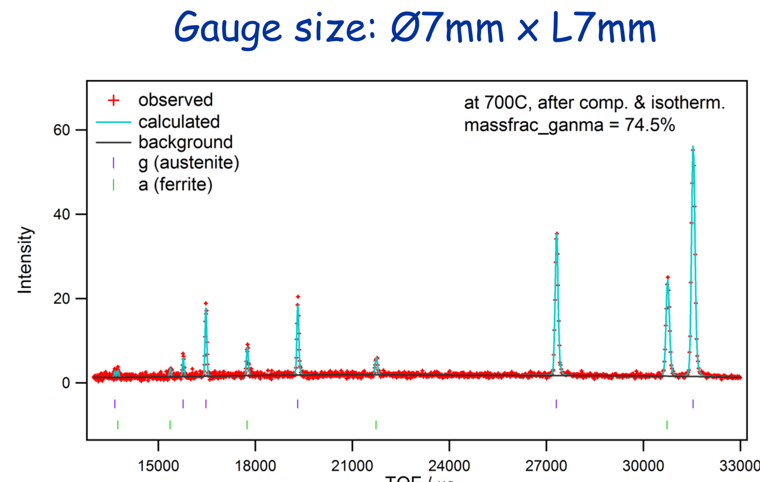
High carbon content film austenite is also formed during bainitic transformation

Thermo-mech. of 2Mn-0.2C steel (-> fast process)

@ 120 kW (2010)

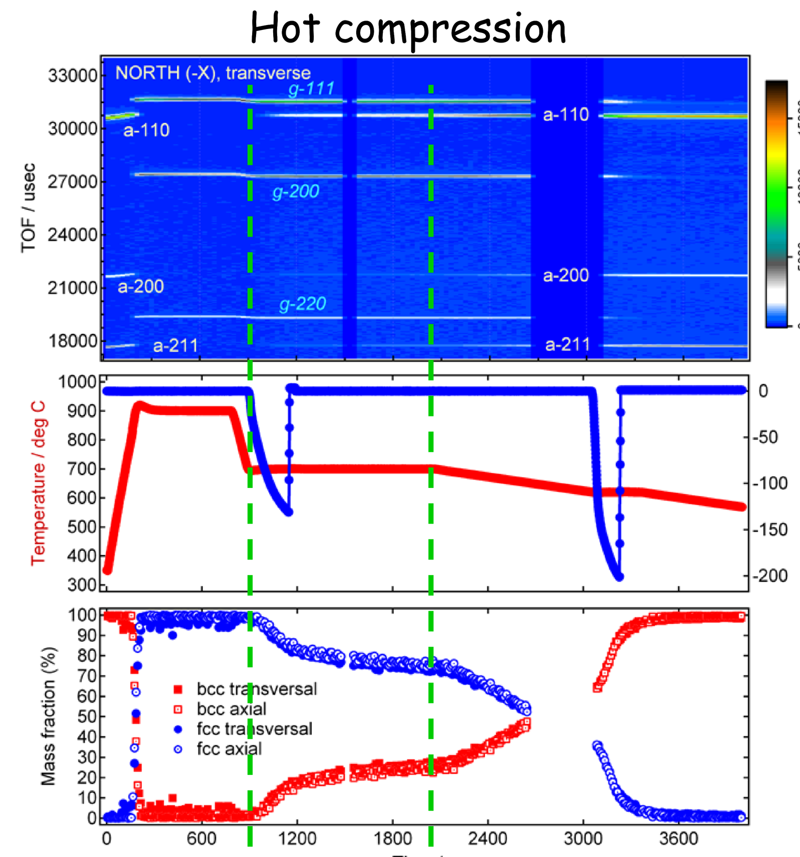


Gauge size: Ø7mm x L7mm



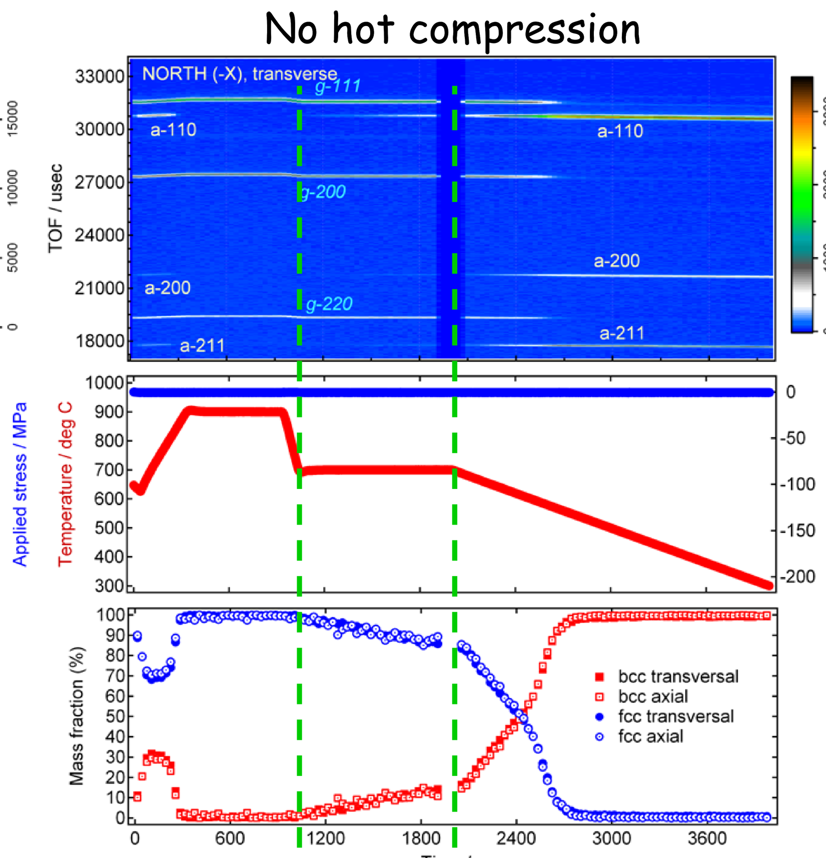
10 s sliced diffraction data (axial dir.)

Hot compression



austenite -> ferrite transformation was accelerated by adding hot compression at 700°C

No hot compression



austenite -> ferrite transformation was slow at 700°C

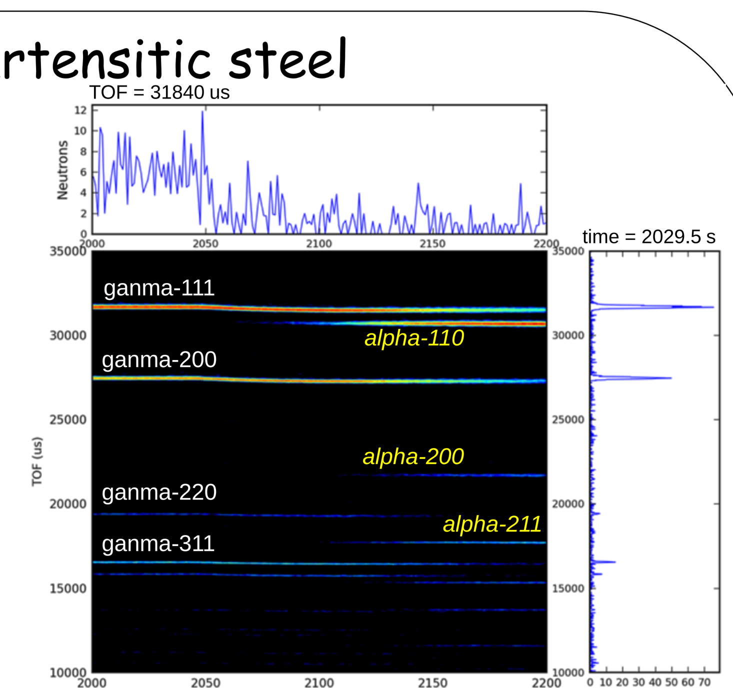
Thermo-mech. of a martensitic steel

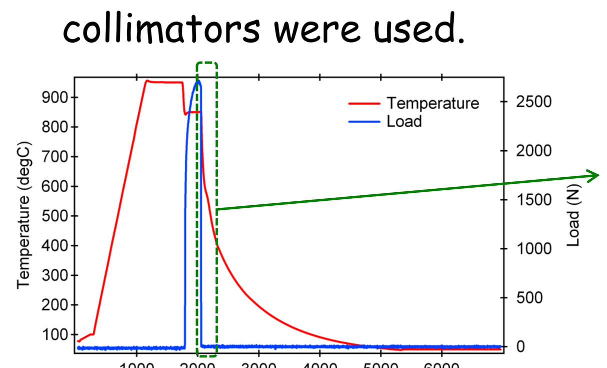
@ 300 kW (2013)

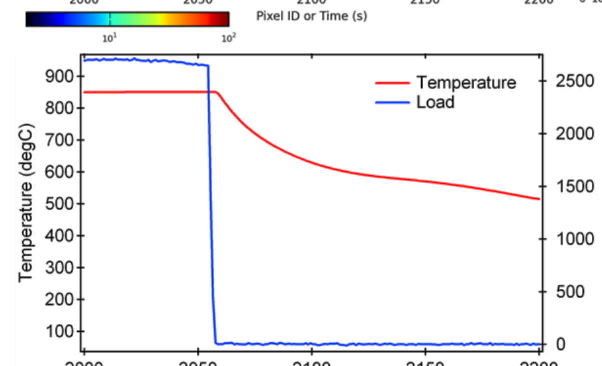
A martensitic steel was used. Heating to 900 C, cooling to 850 C, tensile deformation up to nominal strain of ~25% & unloading at 850 C, cooling.

2D pattern for the axial direction only obtained by slicing data per 1 second.

5mm slit and 5 mm radial collimators were used.



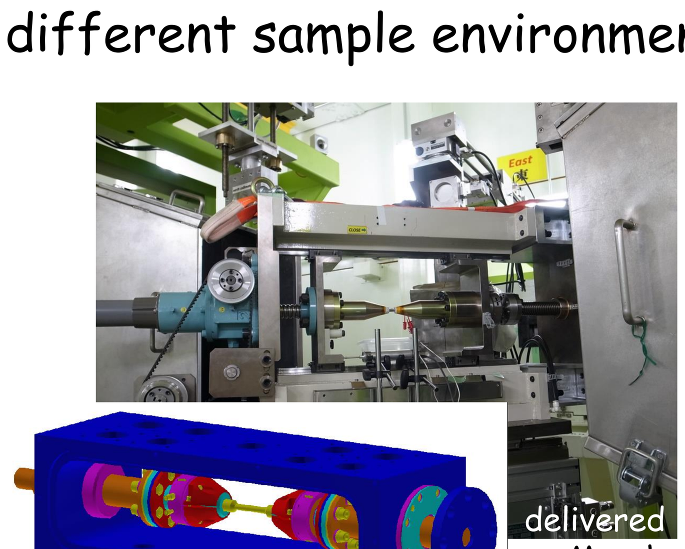




Other possibilities using different sample environmental (SE) devices

Ultra-low temp. loading machine

- Lowest temp: 7 K
- Below 20 K in ~ 3 hours
- Tension only (can be used for comp. with special jig)
- Up 50 kN
- Deformation rate ≤ 100 mm/min
- Load, displacement or strain control



80K chamber for deformation test

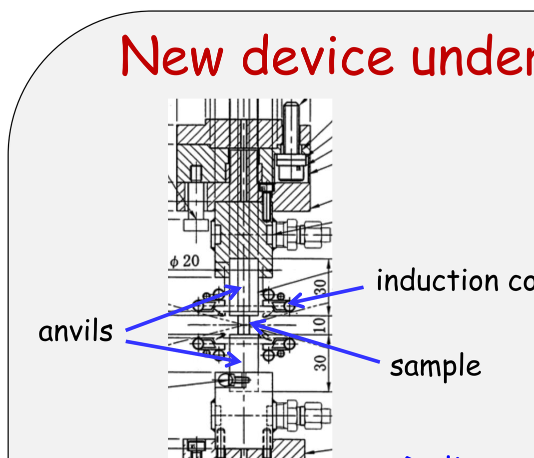
- ~80 K < temp. < 473 K
- Use liquid nitrogen for cooling
- To be added to loading machine
- Tension up to 50 kN, compression up to 30 kN
- Deformation rate ≤ 100 mm/min
- Load, displacement or strain control

Fatigue machine

- Room temperature only
- Dynamic 50kN, static 60 kN
- Fatigue rate < 30 Hz
- Tension and/or compression
- Load, displacement or strain controll

New device under development by CMSI of Kyoto Univ.

Tsuji, Shibata, Oishi, et al.



Thermo-mechanical Simulation System

Brought-in SE

- Highest temp: 1200 C
- Heating/cooling rate ≤ 30C/s
- Deformation rate ≤ 100 mm/s
- Vacuum or inert gas

Delivered until March 2014
Need commissioning during JFY 2014