Experiences in Cavity Fabrication

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Single Crystal Niobium Technology Workshop

CBMM Brasil

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Content

- **Overview of ACCEL activities**
- **General cavity production capabilities**
- **Large grain cavity production**

  Forming of half cells

  Production of large grain single cell 1.3 GHz cavities

  Production of three large grain TESLA cavities (9-cells)

  Production of large grain two cell cavity
- **Single crystal cavity production**

  Production of CBMM single crystal cavity

  Production of HERAEUS single crystal cavity

ACCEL Instruments GmbH

Advanced Technology Equipment and Turn-Key System Supplier for Research, Industry and Medical worldwide

ACCEL site at the Technology-Park in Bergisch Gladbach near Cologne (close to Interstate A4)

Business Units

RF Components and Systems
Linear Accelerators
Specialized Manufacturing Projects

Superconducting Magnet Systems
Circular Accelerators
Proton/Ion-therapy

Synchrotron-Beamlines
X-Ray Systems
Special UHV Equipment

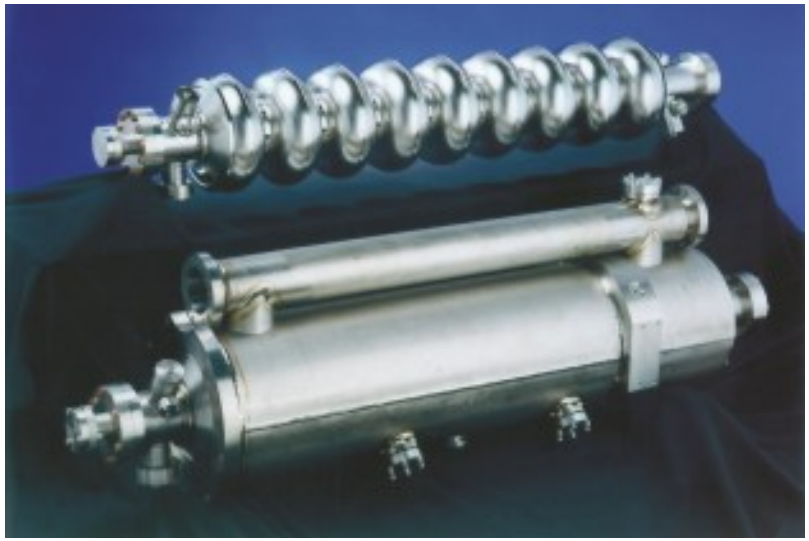
ACCEL Instruments GmbH

1980 - 1993	Siemens AG/Interatom GmbH in Bergisch Gladbach near Cologne „Accelerator and Magnet Technology“
1993/94	Foundation of ACCEL Instruments GmbH, Management Buyout Contract with Siemens AG Production Facilities, Rights, Documentation Regulation Transfer, Guarantees, etc. Transfer of about 30 existing Key People
End of 2006	Staff of 250 People Physicists, Engineers, Manufacturing Specialists, Commercial, Controlling, Administration **Important supplier of SRF cavities, worldwide**

ACCEL history in SRF cavity production

SRF Cavity series production

TESLA cavities (>60) + 30 in production

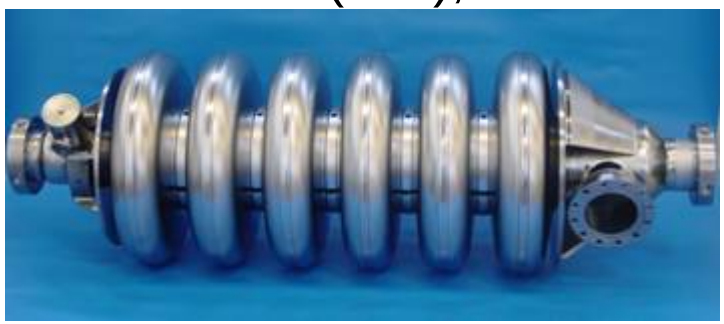


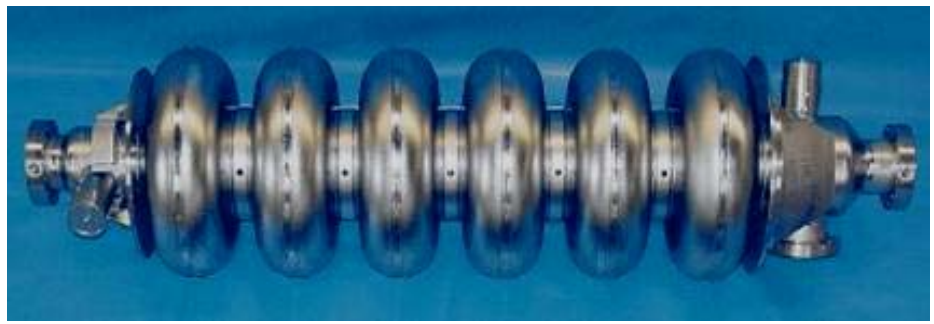
1.3 GHz

CEBAF cavities (300)

1.5 GHz

SNS cavities (109), 805 MHz

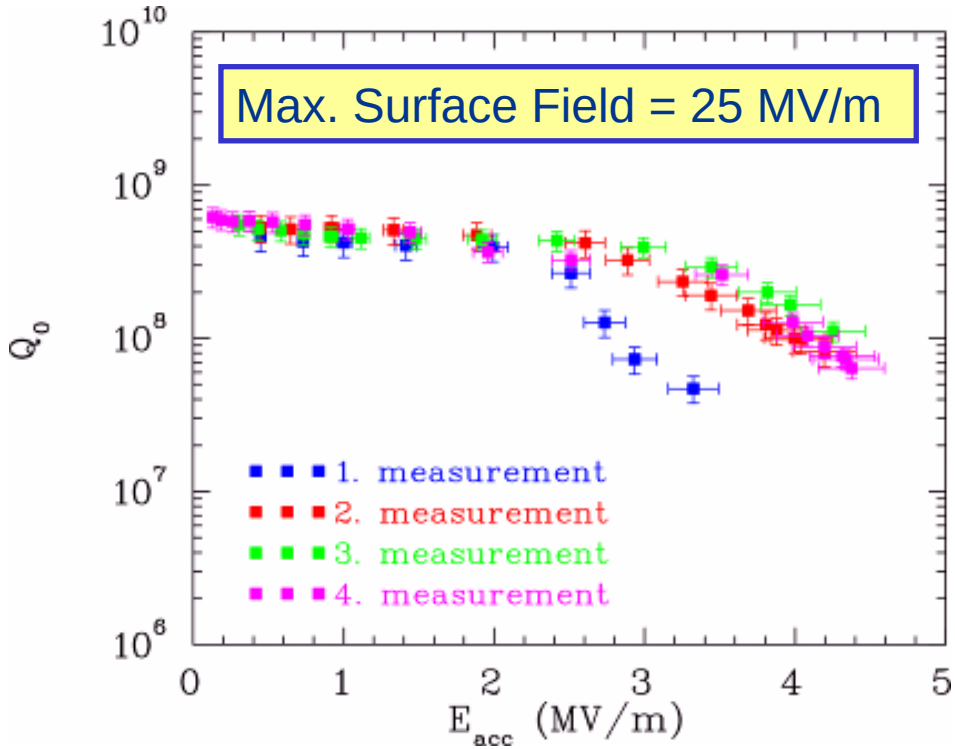




ACCEL history in SRF cavity production (2)

SRF Cavity production: prototypes (example)

Frankfurt CH mode cavity, 357 MHz

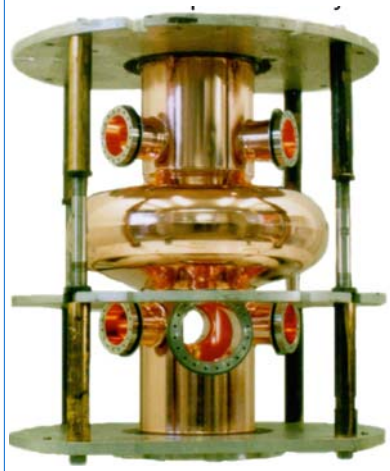


Chemical preparation, High pressure rinsing, assembly in clean room at ACCEL

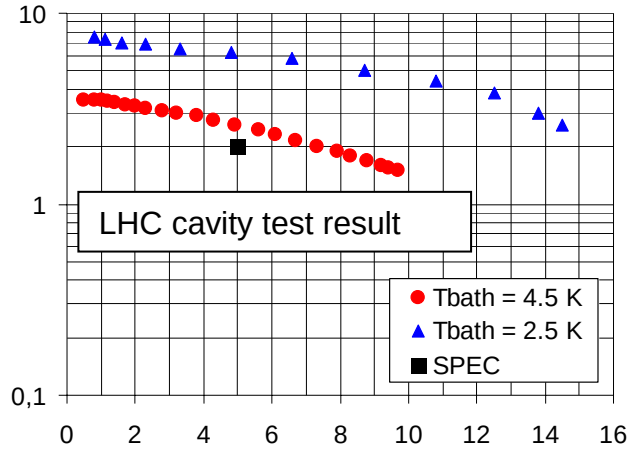
Vertical test at University Frankfurt

ACCEL history in SRF cavity production (3)

SRF Cavity production: Niobium on copper technology, LEP, LHC, Cornell, SOLEIL



LHC (400 MHz) SOLEIL (352 MHz)

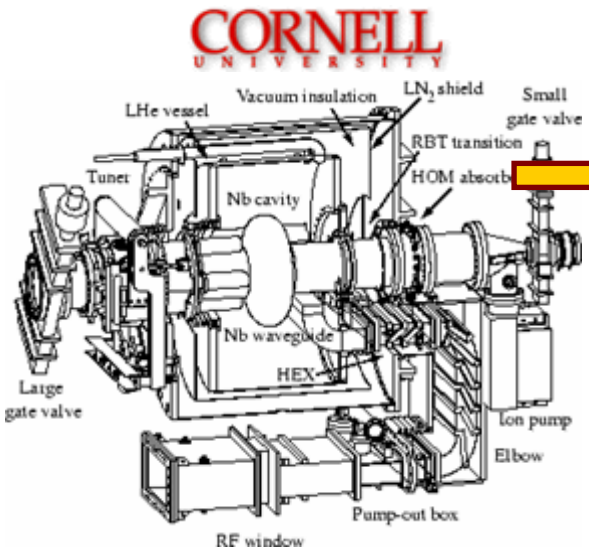


Chemical preparation, rinsing,

assembly in clean room at ACCEL

Vertical test at CERN / Cornell

Cornell modules (500 MHz): technology transfer to ACCEL

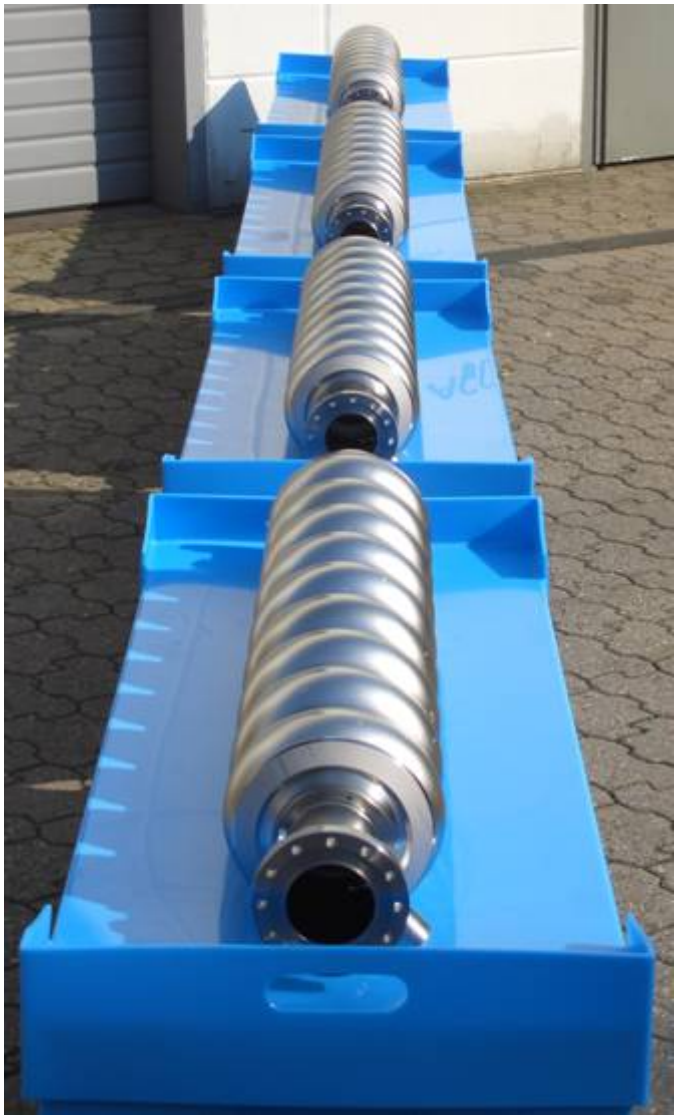


Technology transfer

Each module houses one 500 MHz cavity

2000: 2 SRF modules for NSRRC, Taiwan,
2000: 2 SRF modules for CORNELL, USA
2000: 2 SRF modules for CLS, Canada,
2003: 3 SRF modules for DLS, Great Britain,
2005: 3 SRF modules for SSRF, China
in total 12 SRF modules

Cavities for ILC from standard material

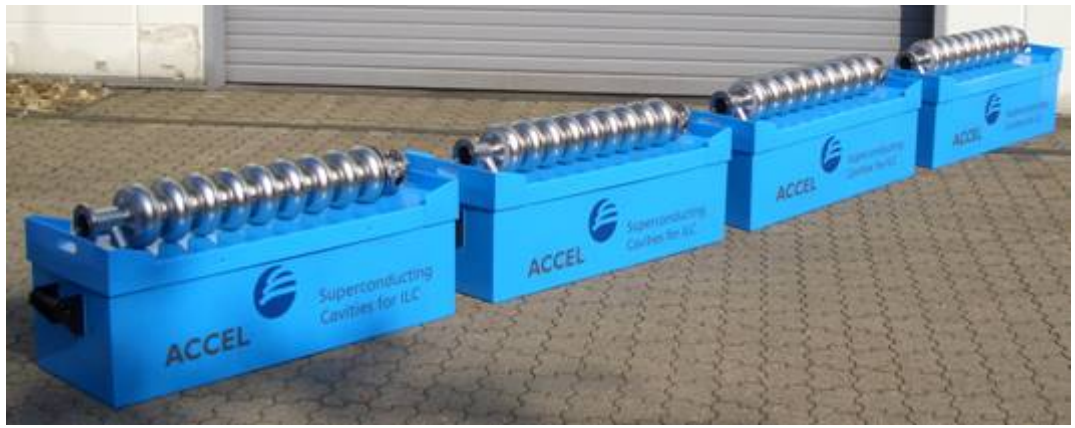


TESLA / ILC cavity: Standard ACCEL product now

Production capabilities:

Have produced one cavity per week for SNS with 2 EB welding machines installed. Operated in one shift operation and welding machines occupied by about 70% for SNS.

Planning to produce up to one cavity per day with 2 shift operation at the EB welding machine, installation of new third EB welding machine and using appropriate tooling to do more multiple welds during one pump down. This will be sufficient for XFEL requirements (1000 cavities in about 3 years).



Large grain half-cell produced by spinning

Heraeus material

- steps at grain boundaries after spinning process
  therefore no advantage compared to deep drawing
- Deep drawing more reliable in view of reproducibility (faster and more automated)

Large grain half-cell produced by deep drawing

Heraeus material

Earing

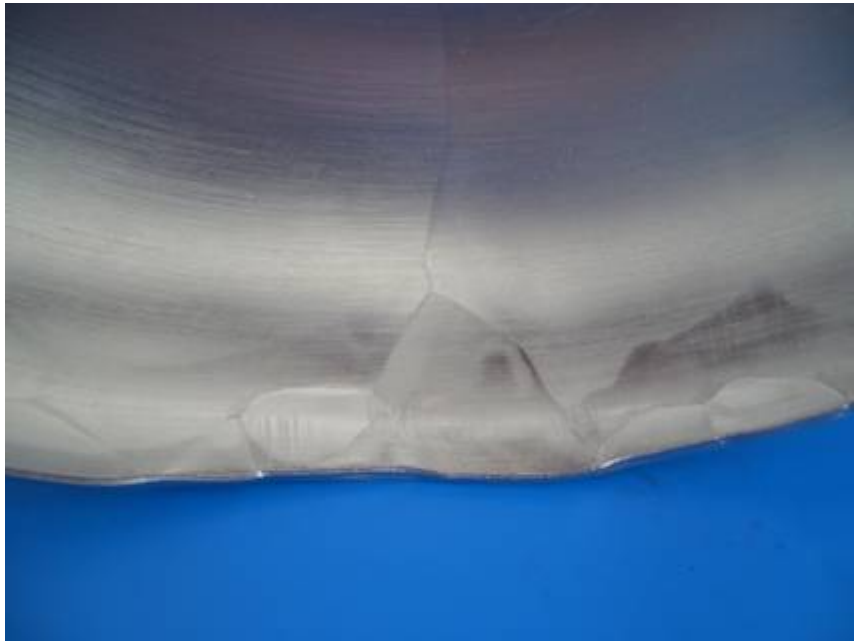
- steps at grain boundaries also present after deep drawing process

Large grain half-cell produced by deep drawing

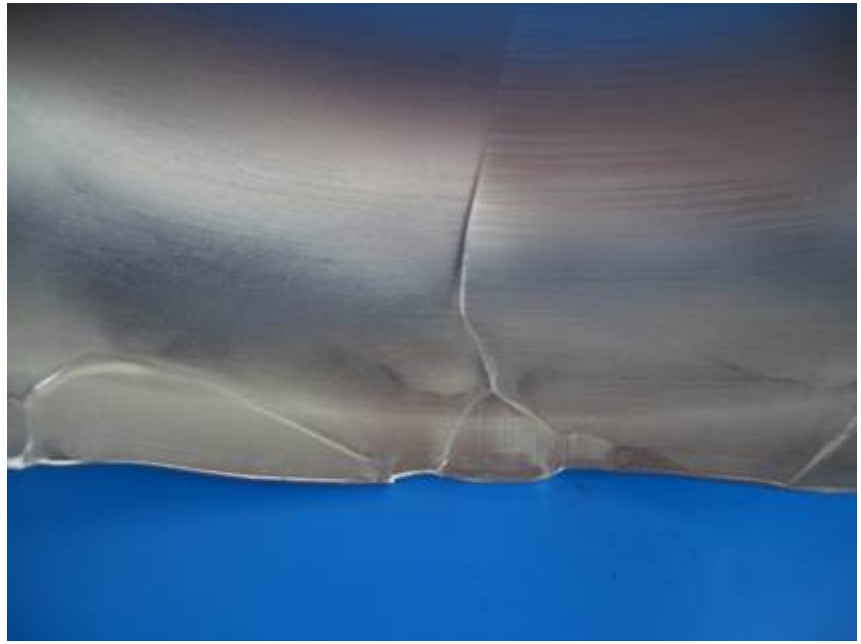
Ningxia material

- thinning at grain boundary in iris region
- Strong earing and grain steps at equator region

Grain steps from forming process



Almost no grain steps



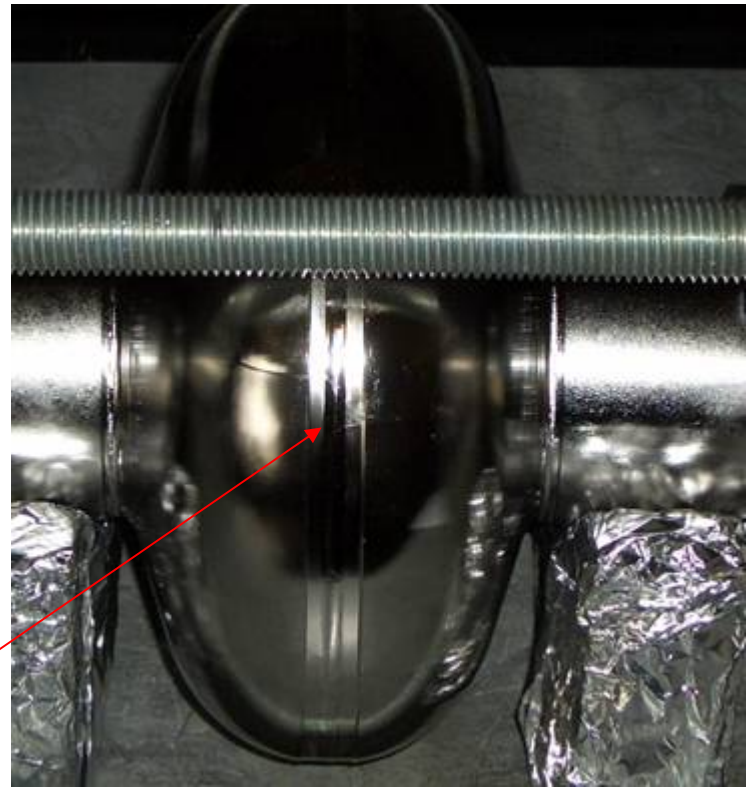
Large grain steps

- possibly room for improvement by variation of deep drawing parameters

Large grain single cell cavity production

- No difficulties to weld beam tubes out of fine grain material to large grain cells
- Equator welds a bit more complicated, as half cells are not as round as from fine grain material. Assembly takes more time and needs some tooling

Grain boundary in the middle of the weld

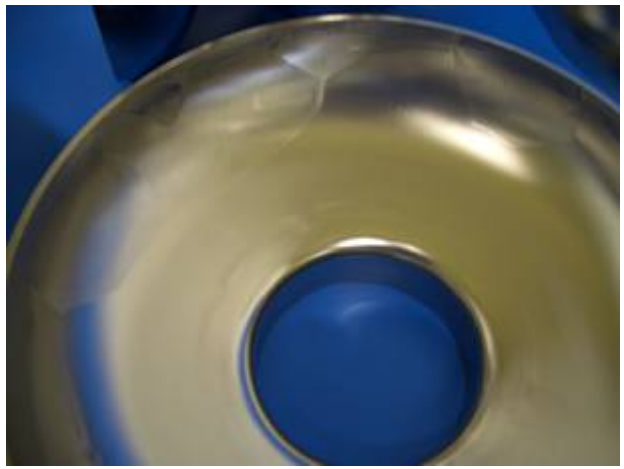


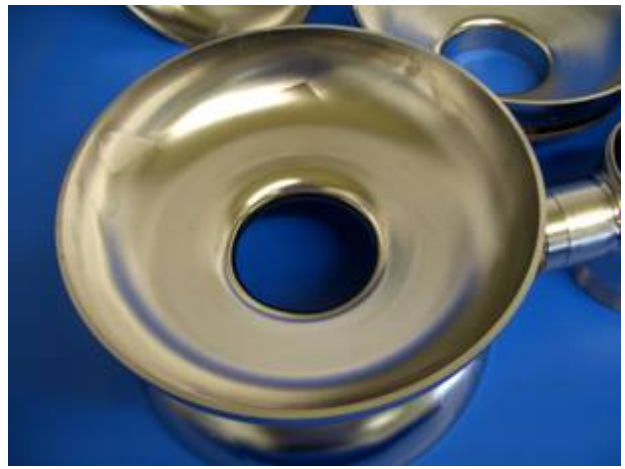
Large grain single cell cavity production

Four large grain cavities produced so far

Large grain 9-cell cavity production

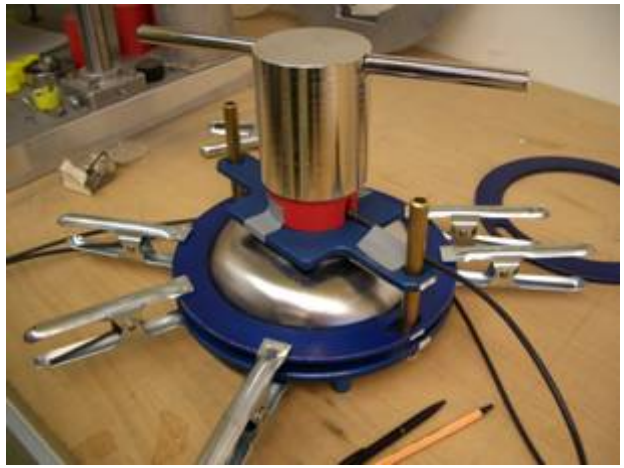
Half cells by deep drawing (stamp and cushion)





Large grain 9-cell cavity production

No problems observed during manufacturing, assembly for equator welds a bit more complicated as cells are not as round as fine grain cells, but basically no difference in production time and cost for large grain and fine grain 9-cell cavity



Frequency control

Large grain 9-cell cavity production

Large grain (front) and fine grain cavity in workshop. Large grain cavity more shiny.

Large grain 2-cell cavity from Ningxia material

Half cells (center cells) produced at PKU, shipped to ACCEL
Welding of special beam pipe and flanges to half cells and completion of cavity done in our workshop
Cavity ready for testing

Single crystal cavity from CBMM material

Single crystal (200 mm diameter and approximately 11 mm thick) was cut in two discs, each 5 mm thick by wire erosion
Half cells produced by spinning
No intermediate annealing during fabrication
Material quite thin at equator after spinning (1.3 mm)

Intermediate spinning step

finished half cell

Single crystal cavity from CBMM material

Inner surface of half cell directly after spinning (no BCP)

No new grains in the equator, complete cell one crystal

Single crystal cavity from Heraeus material

Single crystal was cut in two discs by wire erosion
Single crystal enlarged by rolling (at RWTH Aachen)
Intermediate annealing after rolling
Deep drawing of half cells, final welding

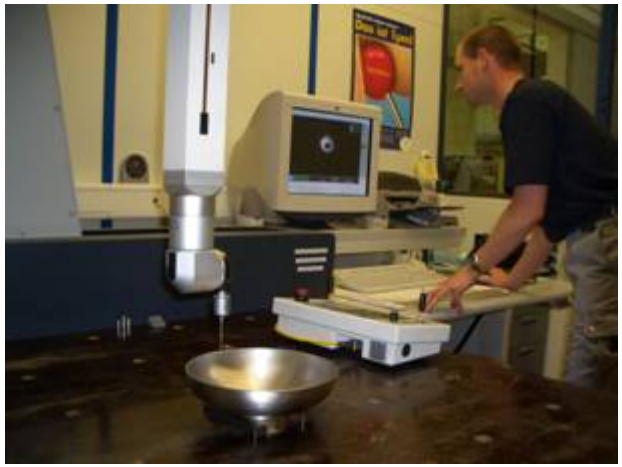
Material before and

after rolling

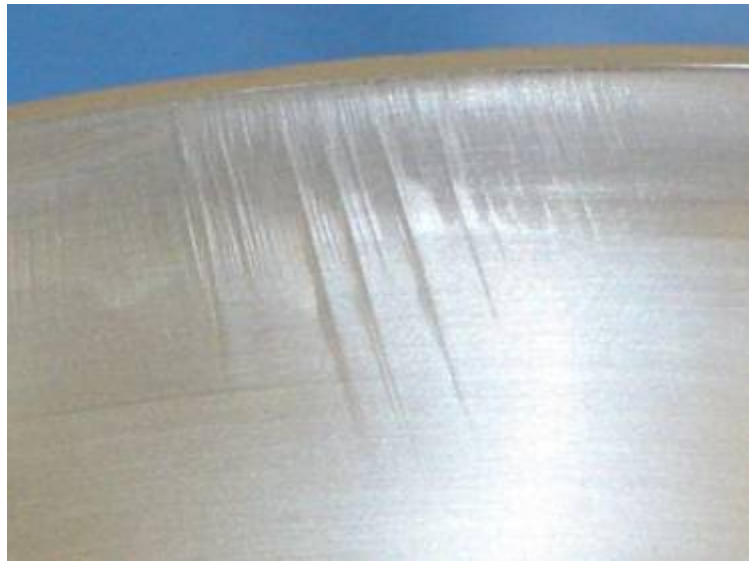
Single crystal cavity from Heraeus material

Half cell after deep drawing

Dimensional control of form



Overlapping of material at equator



No new grains in the equator, complete cell one crystal