Low Field Quench, HAZ Pits and Strain in a Prototype Cavity for the European XFEL

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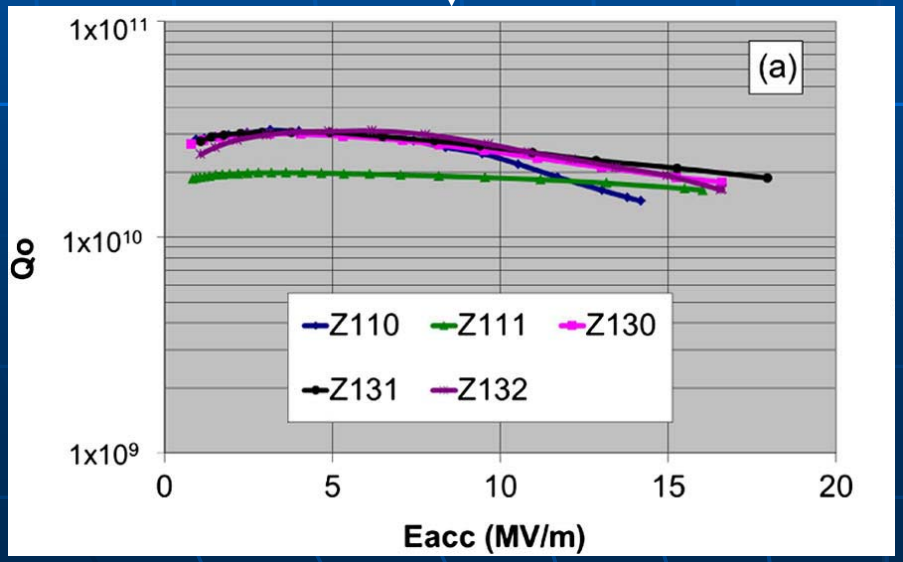
Analysis of results from:

W. Singer, X. Singer, S. Aderhold, A. Ermakov, and K. Twarowski, R. Crooks, M. Hoss, F. Schölz, and B. Spaniol; “Surface investigation on prototype cavities for the European X-ray Free Electron Laser,” PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS 14, 050702 (2011).

Work funded by W. Singer, Deutsches Elektronen Synchrotron

Overview

- Some SRF Cavities manufactured for the European XFEL showed thermal breakdown without field emission a low accelerating gradients
- Thermometry indicated hot spots in the equator weld region
- A hot spot region from one cavity, Z111 (**17 MV/m** quench), was removed by dry, slow speed, hole saw milling and examined by Scanning Electron Microscopy and Electron Backscattered Diffraction
- Comments on **Deep-drawing Strain, HAZ and Pits**
- Correlations were made between *stored strain energy and pits in hot spot sample*, use of GROD for relative dislocation density



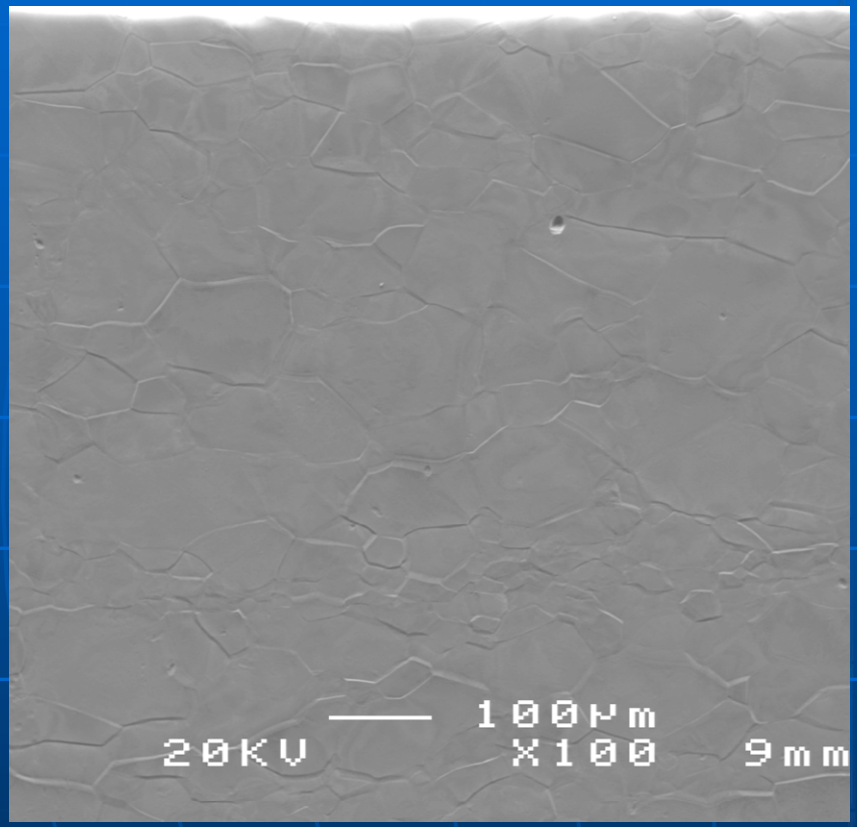
Treatment of Z111:

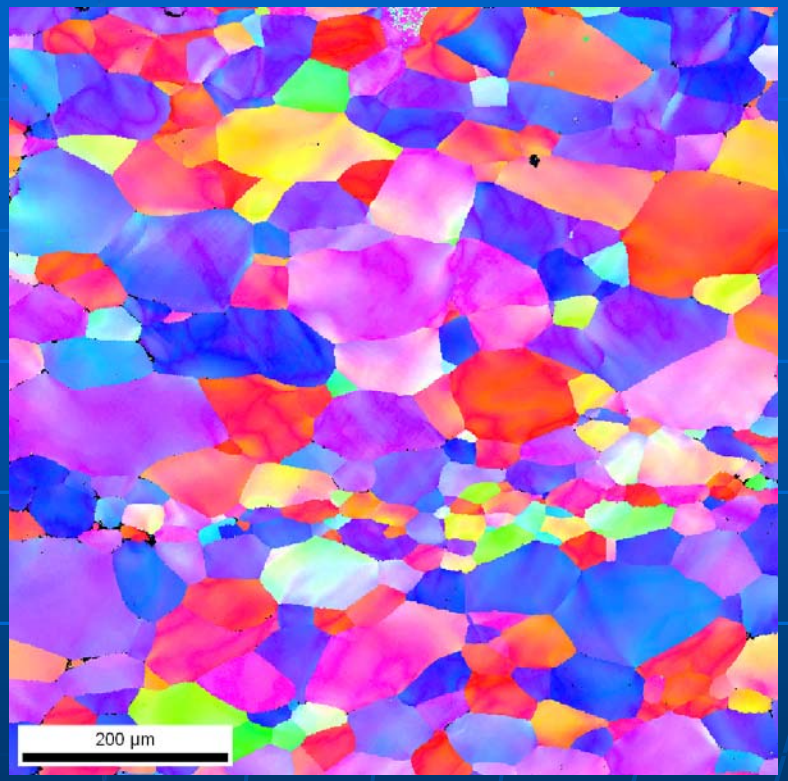
- > 100 µm removed by EP
- ~10 µm removed by BCP
- 120°C bake
- rf testing at DESY with thermometry

- hot spot removal (X. Singer)

Background: Deep Drawing Strain

inside surface

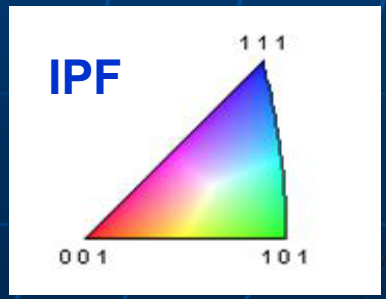




~ 20% strain

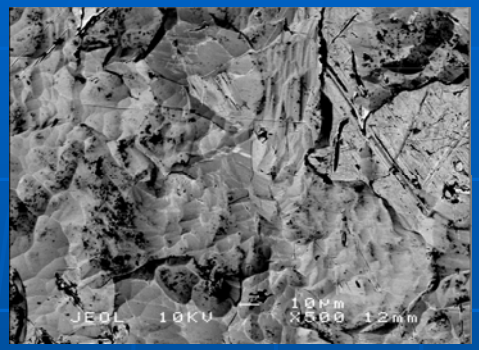
Mark III CEBAF Cavity

95% hit rate, 560,200 data points,
1 µm spatial resolution



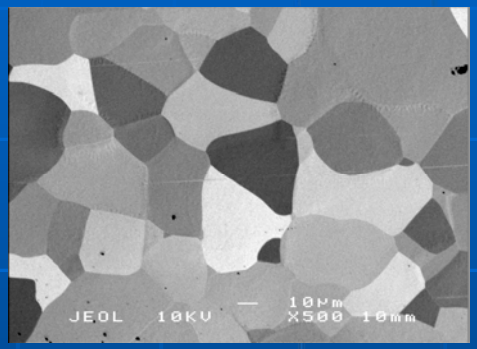
Background: AR EP Sheet Compared to Deep Drawing Strain at Equator

AR



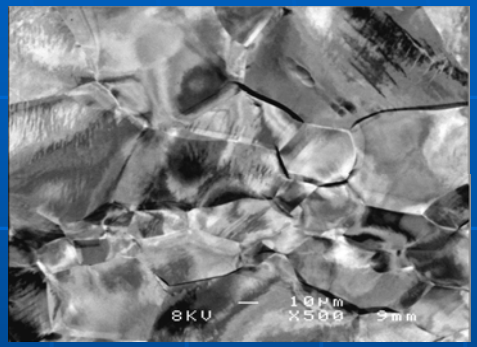
BEI

EP



BEI

Deep-drawn Cavity Equator



BEI

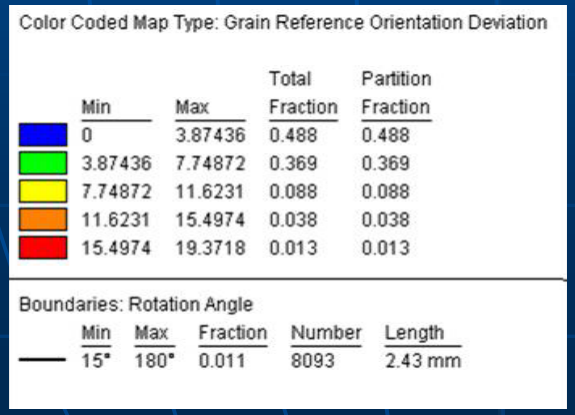
High strain removed by welding?

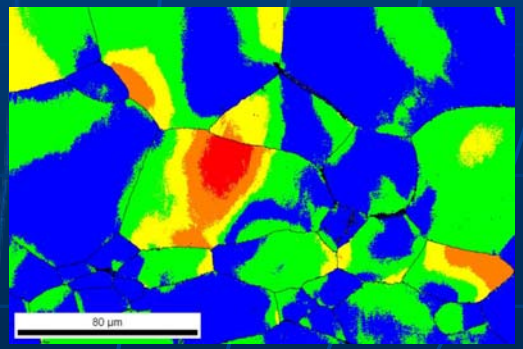
How much strain?
lattice curvature ~ 1°/µm

~ 20% strain

EBSD GROD Map 500 µm from interior, 3 mm from lip

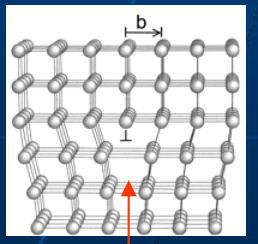
0.3 µm spatial resolution





EBSD

Edge Dislocation



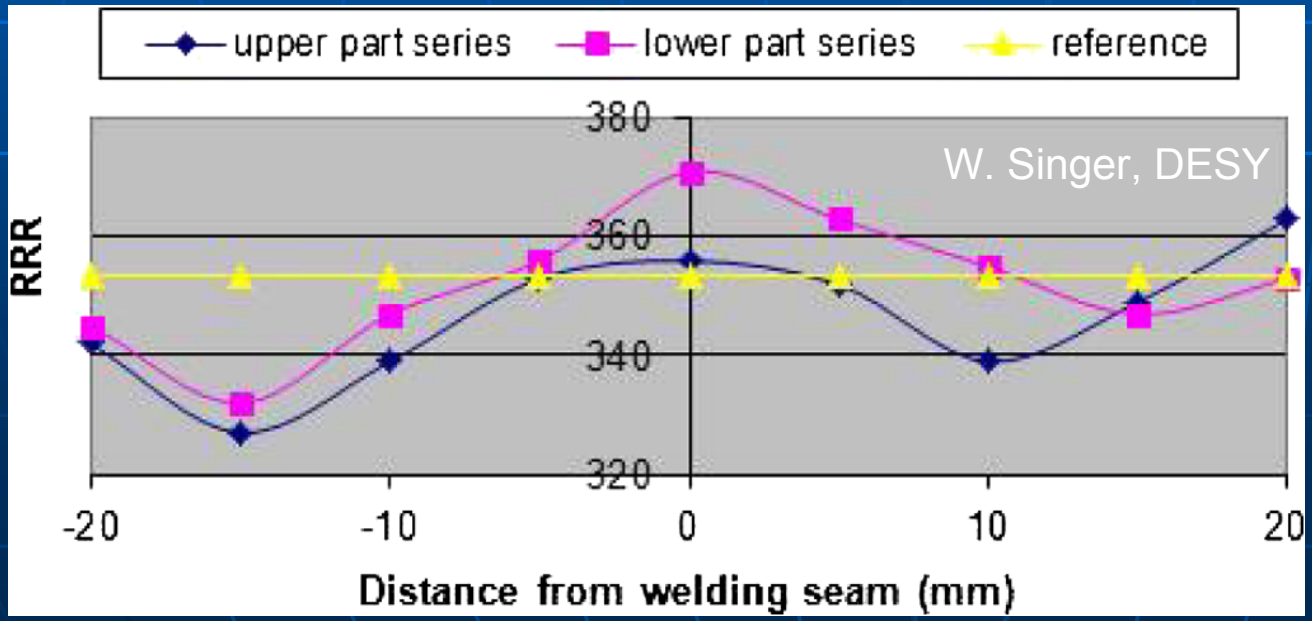
interstitial site

Background: Equator welds, HAZ pits and RRR drop

HAZ exposed to high T

Quench related to topography (pits)?

K. Watanabe, *Recent Inspection Results by Kyoto-Camera*, in *TESLA Technology Collaboration Meeting*. 2008: New Delhi, India.



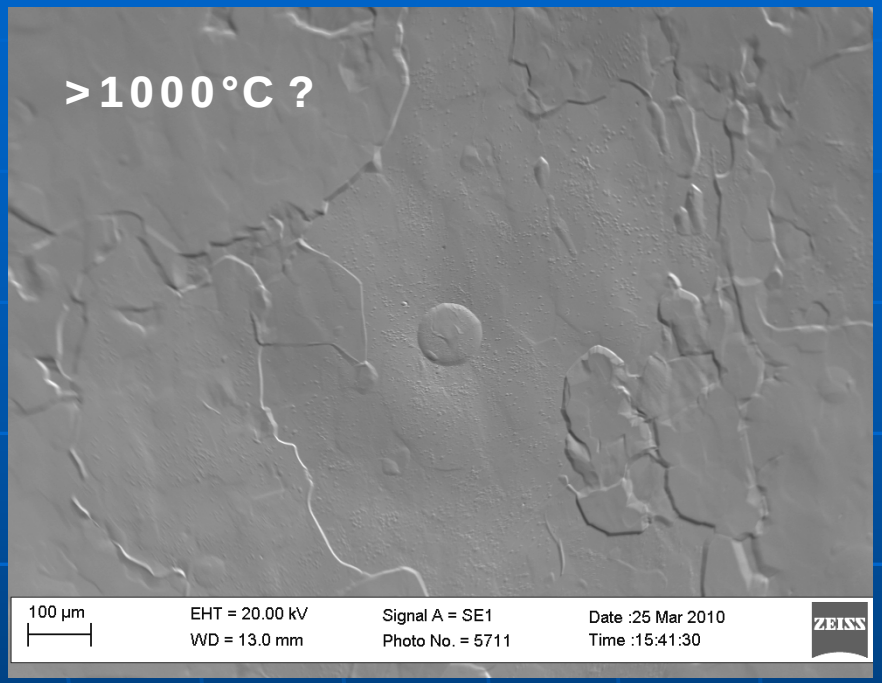
Low RRR related to HAZ?

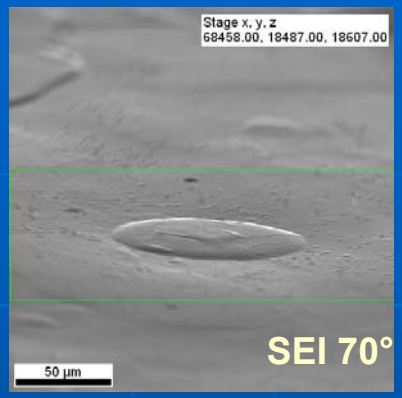
Diffusion of interstitials to dislocation sinks?
During welding?
During ep?

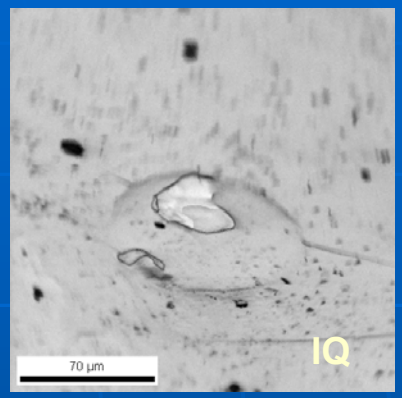
Oxygen lowers Tc and Hc.

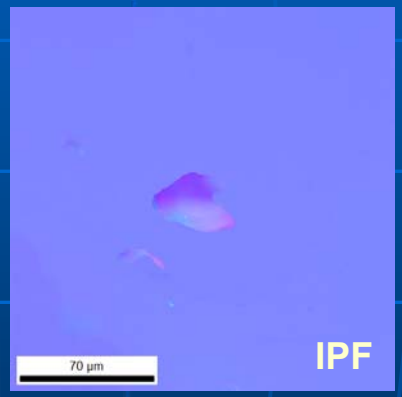
Other impurities?

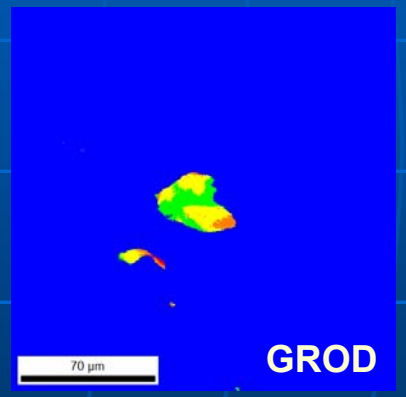
HAZ pit and “pocket of strain” in Z111











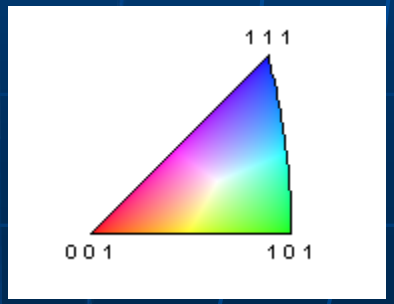
Pit about 2 mm within HAZ

Strain region part of larger grain, no high angle g.b. > 15°

How much strain?
lattice curvature ~ 3°/µm

(greater than as- formed data)

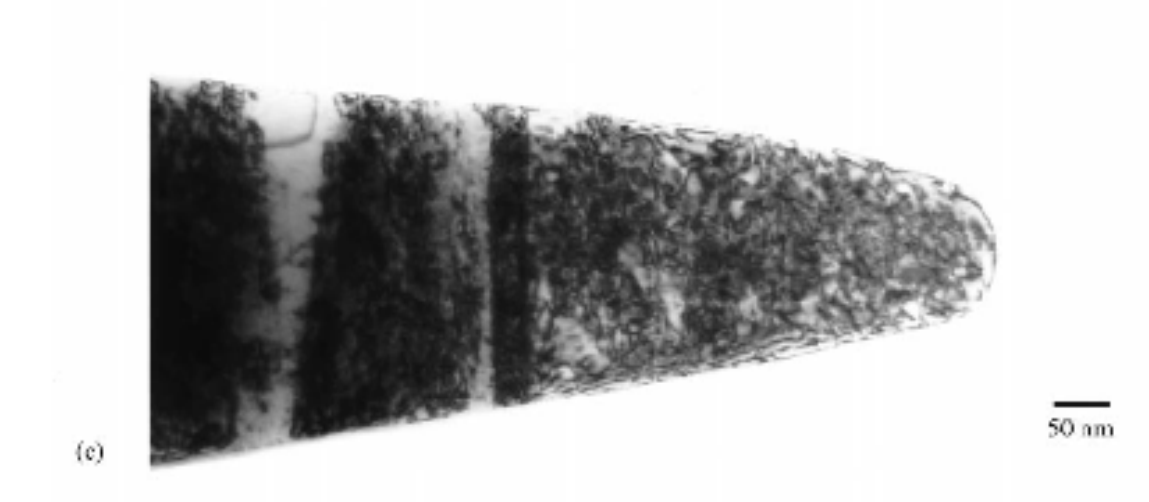
200 x 200 µm, 0.5 µm resolution



	Min	Max	Total Fraction
	0	2.0103	0.977
	2.0103	4.02061	0.009
	4.02061	6.03091	0.011
	6.03091	8.04122	0.002
	8.04122	10.0515	0.000

3DAP Sample (Fe alloy)

high dislocation density maintained

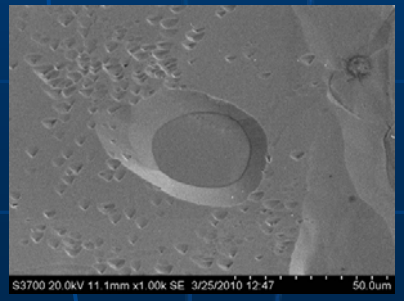


J. Wilde, et al., Scripta materiala, 43 (2000) 39.

Conclusions and Conjecture

- Correlation found between low Eacc quench, hot spot, pit and strain
- Pocket of high dislocation density within pit in HAZ
  - "left behind" in (> 1000°C) recrystallization of HAZ
  - dislocations are sinks for interstitials
    - high resolution (3DAP?) study appropriate to verify dislocation atmospheres, interstitial concentration, chemistry
- Do dislocation atmospheres stabilize dislocations and inhibit recrystallization?
  - questions of diffusion, recovery and recrystallization rates during a brief thermal excursion
- Hot spot due to impurity concentration rather than topography?

> 100 µm removed by EP
~10 µm removed by BCP
120°C bake



~ 80 µm diameter
~ 10 µm deep