Recent results on laser remelting to repair pits

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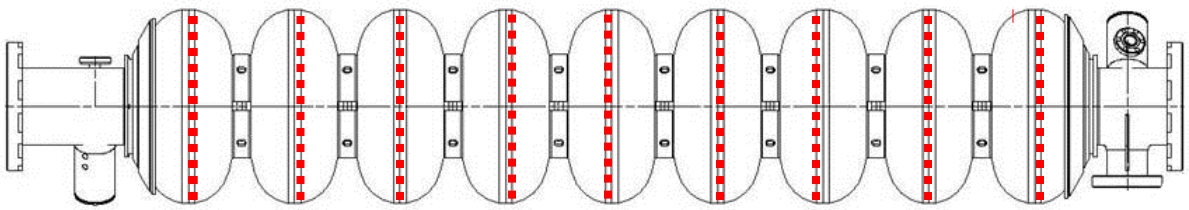
Outline

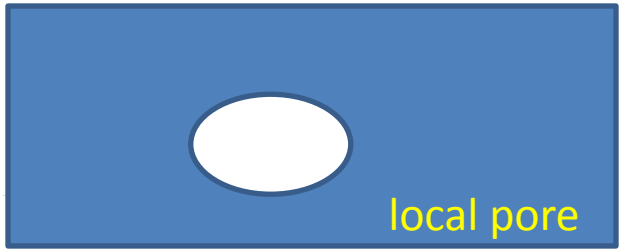
- Why local melting?
  - repair weld defects without *bulk removal*
    - this might uncover new defects
  - feasibility shown on single cells, being adapted to 9-cells now
- Technique
  - basic elements
  - sensitive to parameters: power, cover gas, focus, alignment…
- Results
  - oxidation
  - geometrical re-construction of the defect
  - microstructure

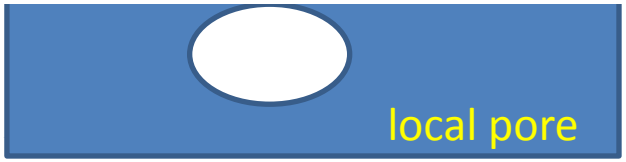
State of the art: defects, quenches

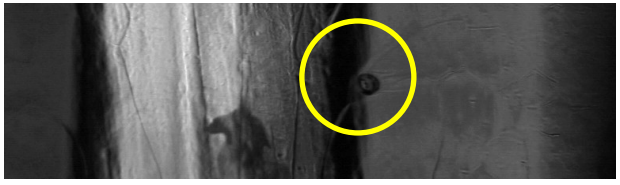


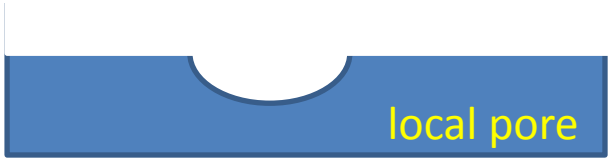
1 of ~50 welds is limited by quench at a single defect

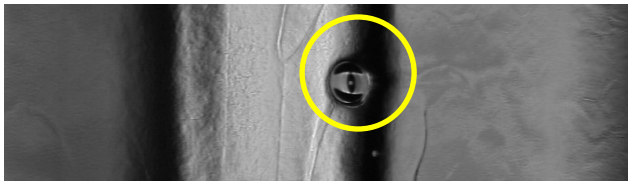
1 of every 6 cavities is limited by a weld defect











Iris defect uncovered by sequential polishing and tracked by optical inspection
(Cavity TB9RI026)

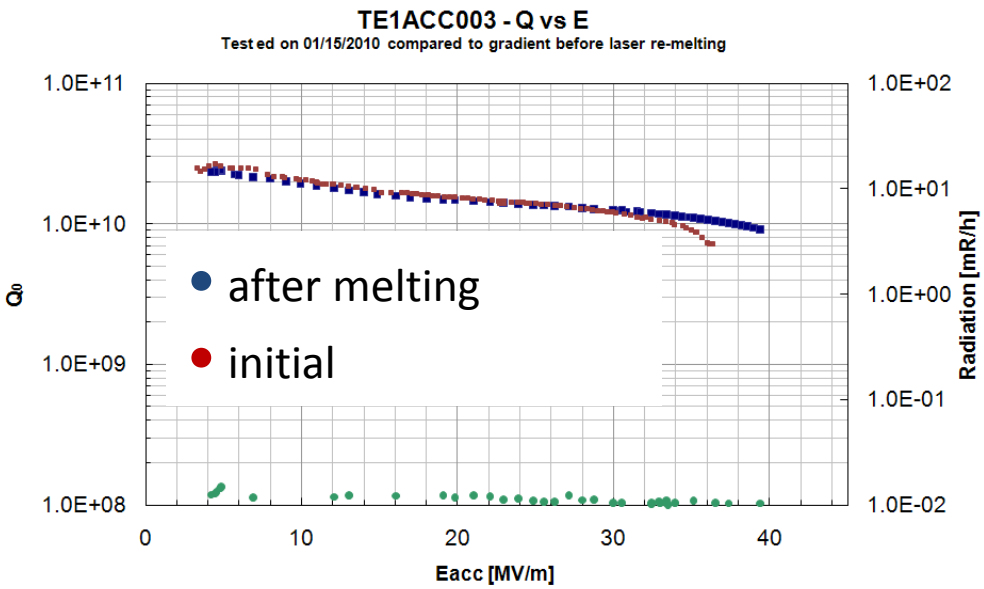
D. Sergatskov (FNAL)

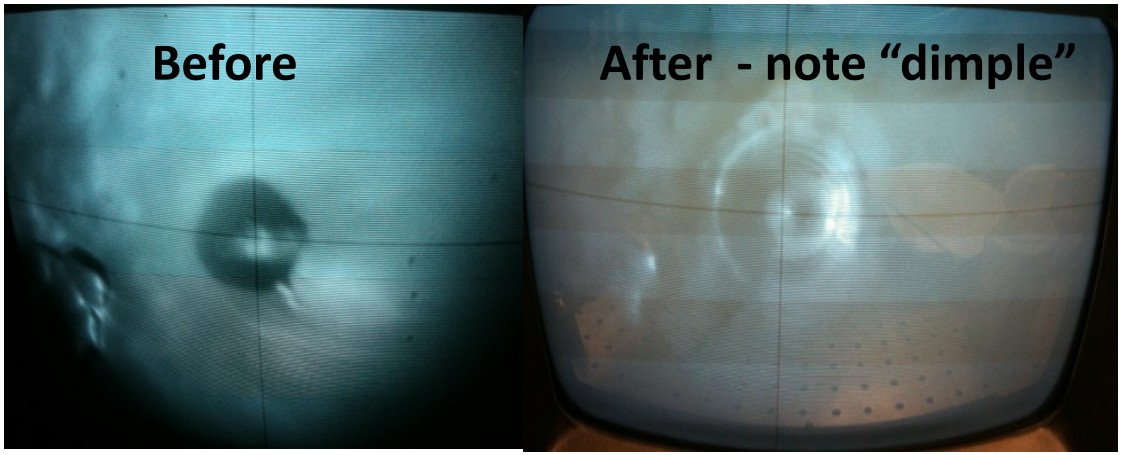
Implication: Repair by either local grinding (KEK technique) or local re-melting

First Engineering Attempt

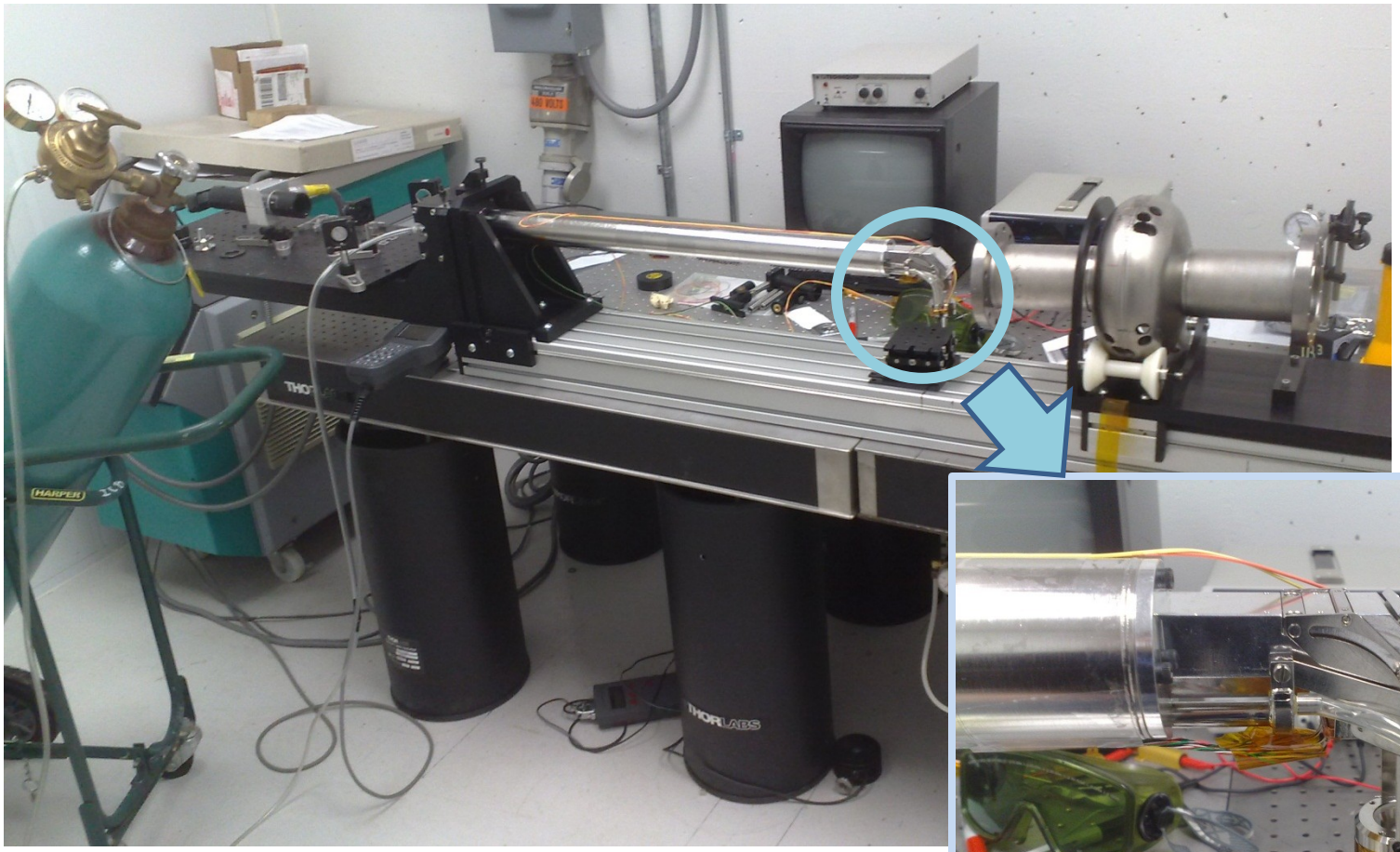
36 MV/m → Melt → 50um EP + 120^0 C → 39 MV/m

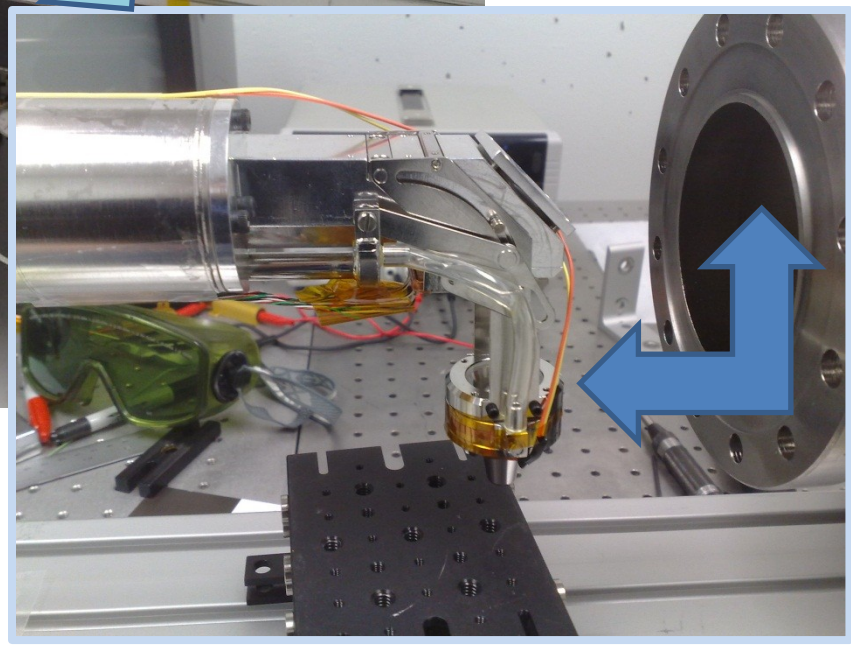
- Mingqi Ge and Genfa Wu demonstrated proof of principle on single-cell
- Melted spot did not reduce gradient or Q appreciably
  - **Do we need post processing?**
  - **Are the parameters optimum?**
- 9-cell apparatus built
- 9-cell melting applied to cavity limited to 12 MV/m by a pit
  - Waiting for final EP now





Ge and Wu setup



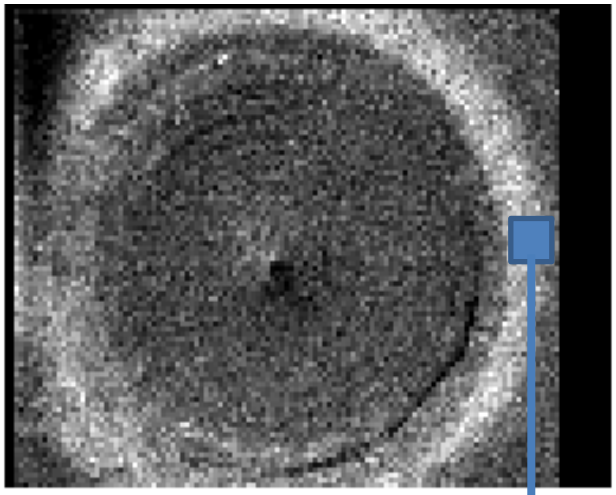


Complex articulation of nozzle for cover gas arranged around mirror and lens for laser focus

Scientific challenges & results

- High temperature required
  - Promotes oxidation, which adversely affects superconductivity

(**Do we need post-processing? What kind?**)

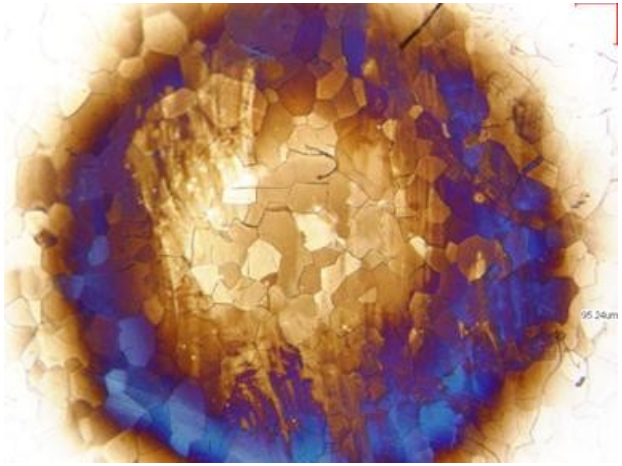


O Ka1

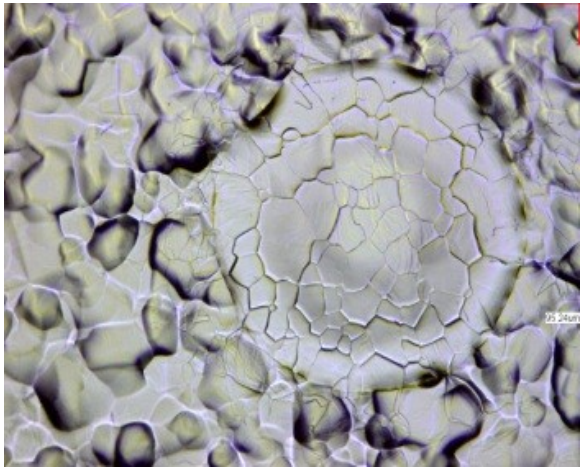
Ring-like oxide layer

Based on EDX peak heights, thickness is only a few µm (not 50 µm)

Low cover gas flow

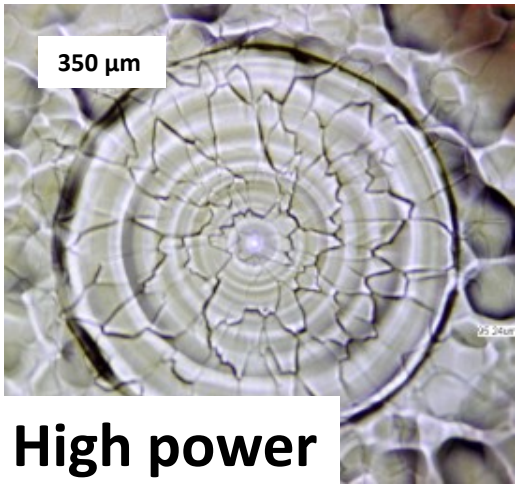


High cover gas flow

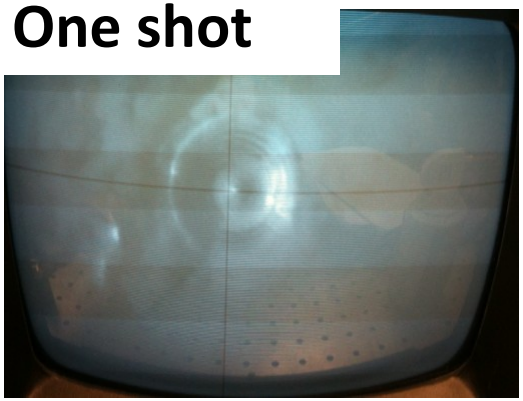


Scientific challenges & results

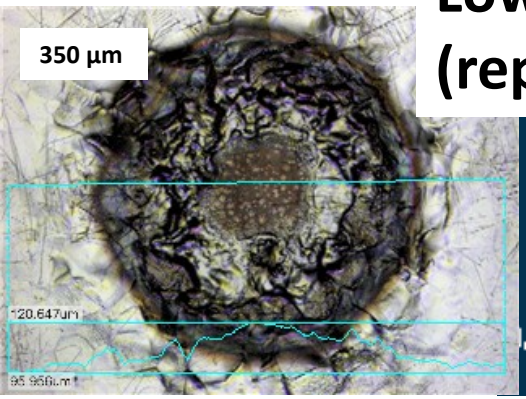
- Risk - Not enough improvement in topography after melting (**Are the parameters optimum?**)
  - "Impact crater" at high power
  - Flatter but more oxidized for multiple low power pulses
  - Can a perfectly flat surface be obtained starting from a defect?

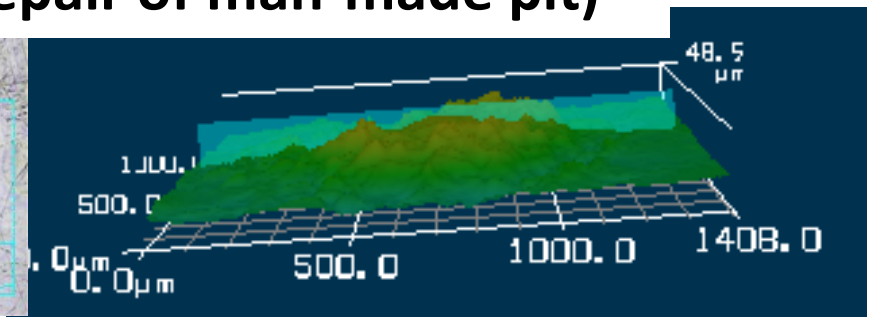


High power
One shot



Low power, multiple shots
(repair of man-made pit)



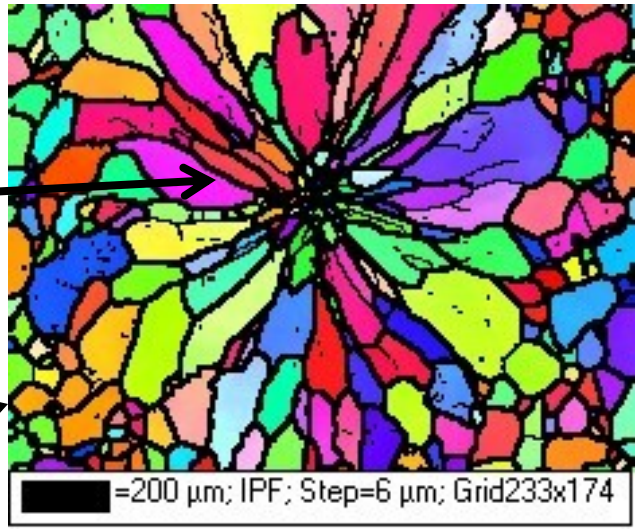


Scientific challenges & results

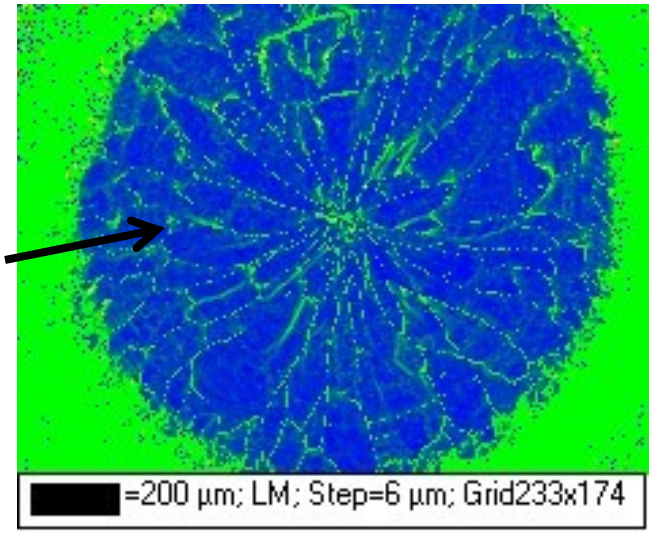
- **Do we need post-processing? What kind?**
  - Some is ok, too much means there is no benefit to overall process
  - Laser melted spot has features like those near a weld (e.g. HAZ)
    - Will this adversely affect post-processing?

Solidification along thermal gradient

HAZ



Evidence for stress along boundaries



Conclusions and Plans

- **9-cell test of initial laser melting parameters (Ge and Wu) is underway**
- **Pathway toward further optimization was demonstrated**
  - *Melting is rather sensitive to power, cover gas pressure, focal distance*
  - *Solution to the "impact crater" problem by multiple low-power shots*
  - *Oxidation occurs, but was found to be rather thin*
    - A few µm post process, e.g. HF etch, could be appropriate
  - *The melted areas have microstructures like welds*
    - Resolidified and recrystallized grains, heat affected zones
    - Dislocations can concentrated in boundaries - stress
- **Future work:**
  - *Obtain the exact depth concentration of oxygen and hydrogen (SIMS)*
  - *Repair low-field quench in 1-cell cavity with new parameters and new post-processing*

Acknowledgments

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Thank you for your attention