Topographic contribution to non-linear rf losses: FG BCP cf. EP

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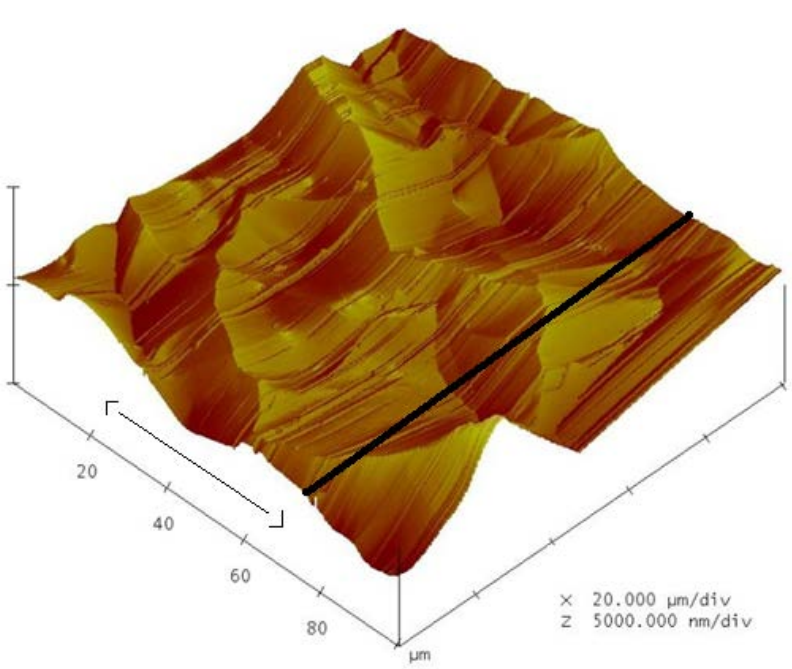
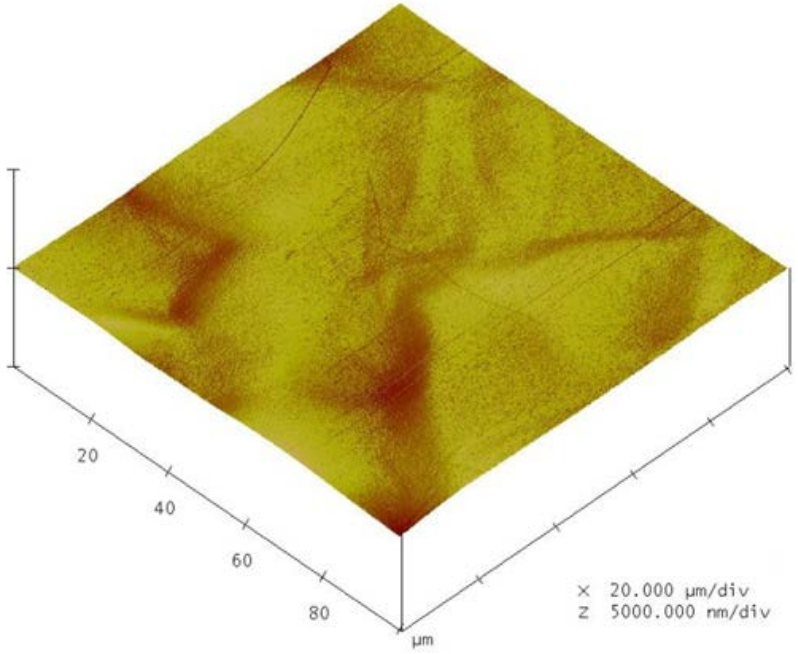
RF Loss Enhancement by Topography

- Local field enhancement at interior sharp edges yield “premature” performance limitations.
- Sharp corner in WG coupler limited LE5-cell cavity design – 1983
- Knobloch et al. suggested non-linear losses due to grain boundary enhancements.
- C. Antoine et al. began grain-edge field enhancement characterization at quench site in 2003.
- Microscopic roughness “looks bad”, but what really matters for cavity high-field performance?
- How much of the BCP vs EP high field performance difference is due simply to topography?
- **What roughness matters?**

BCP vs EP Topography

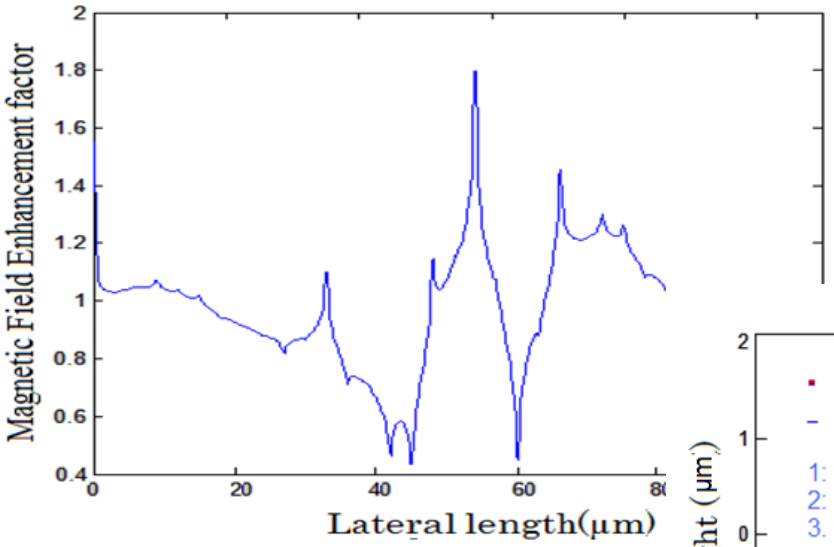


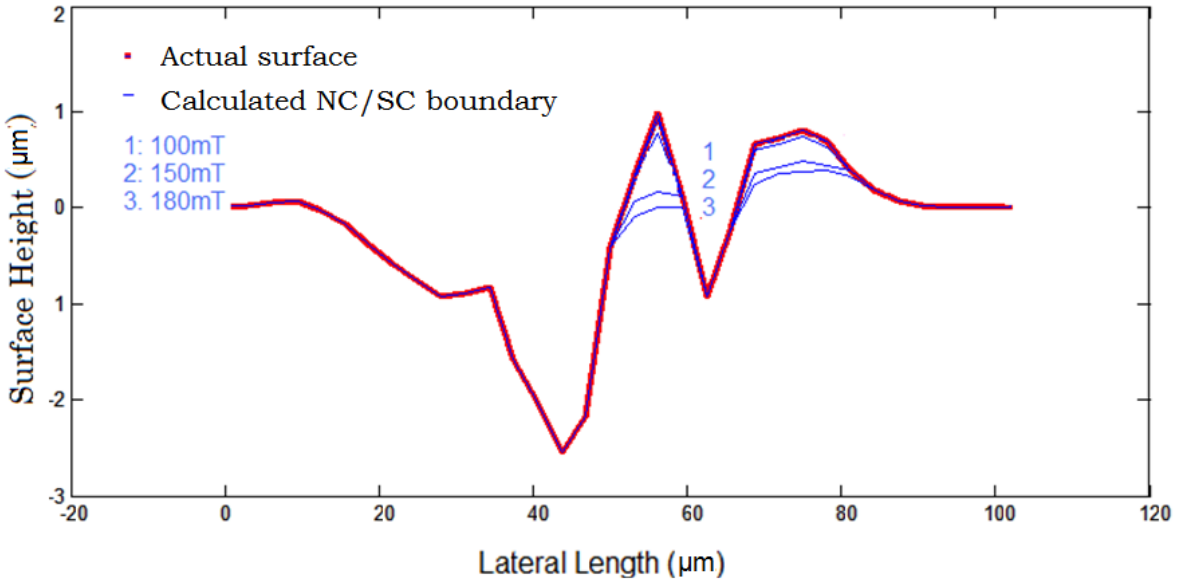


AFM images from a fine grain niobium sample with a) ~ 100µm removal by BCP, b) after EP to remove 48 µm. Horizontal scale is 20 µm per division and vertical scale is 5 µm per division.

PRST-AB 14, (2011) p.123501

FG BCP Topography

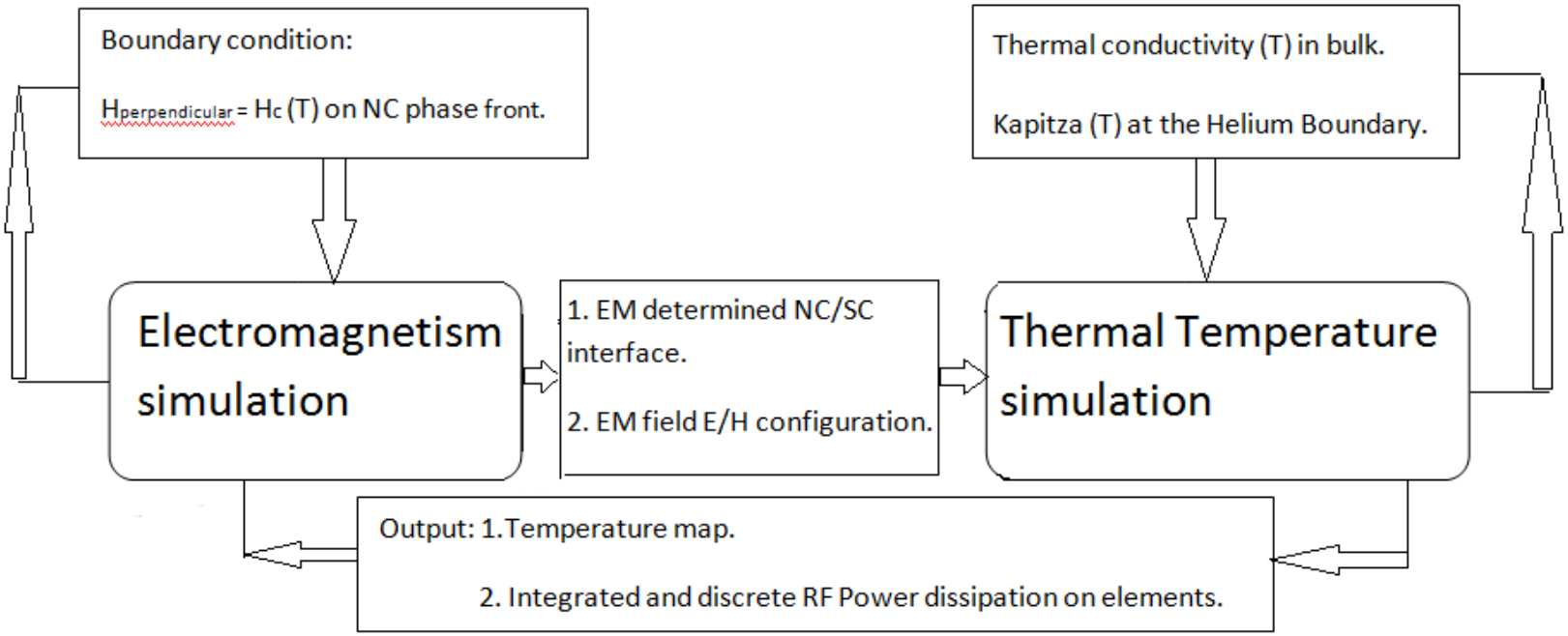




Treat the volume where $H > H_c$ as normal material, but $T < T_c$.
Depth is less than normal skin depth.
Thermally stable because very small local volumes.

IPAC12 Chen Xu *et al*.
SRF2013 Chen Xu *et al*.

Simulation Structure



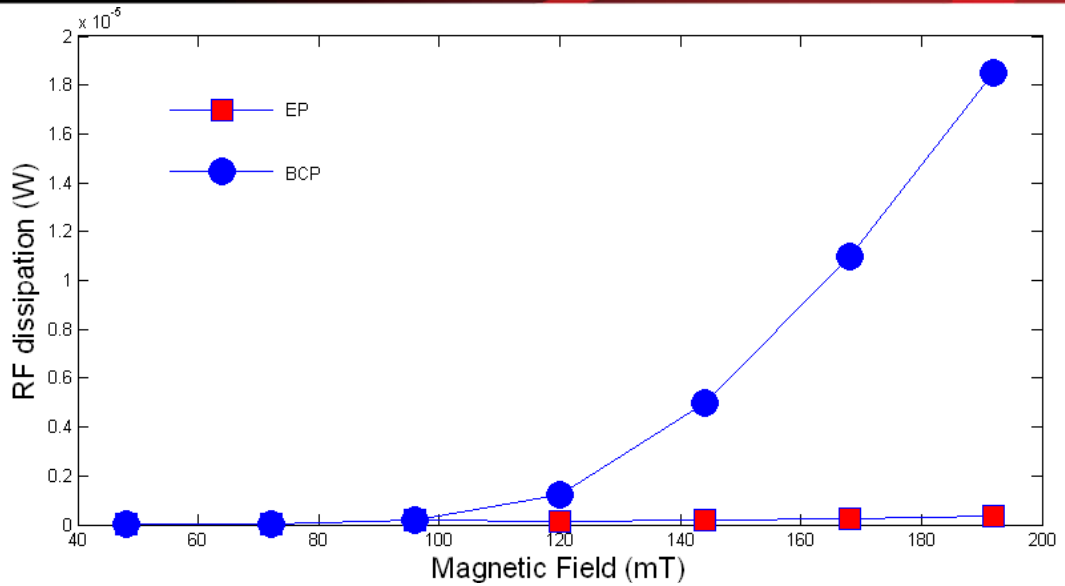
Flow chart of electromagnetic and temperature numerical simulations.

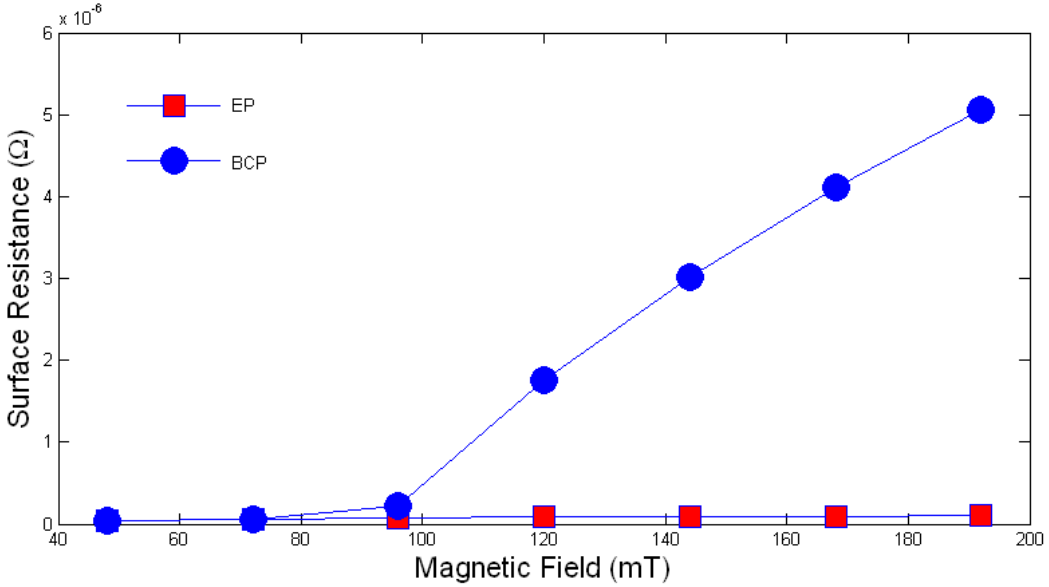
(Chen Xu PhD dissertation, W&M)

Effective R_s due to BCP and EP Topography

- Average the dissipated power over representative 100 × 100 µm surface
- Convert to effective surface resistance with applied H
- Repeat with EP-derived topography
- Model neglects increased R_s of SC material with increasing T

Chen Xu, to be published





Effective R_s due to BCP Topography

- Compare with BCP vs EP performance of a JLab cavity
- Analysis can be improved by using a finer mesh.
- In qualitative agreement with experimental experience.