Drivers of Materials R&D

The basic set of motivating questions:

1. What material features produce quenches, increase in Rs?
2. How do we prevent the material features above from occurring? What material forming and/or processing methods can minimize the occurrence of the above, for the minimum cost?
3. How are surface resistance (Rs) and Q(E) affected by
   - impurities? grain boundaries? surface layers? topography and length scale?
   - secondary or combined effects (e.g. diffusion of impurities down grain boundaries)?
4. How do we describe the target surface and how can it be obtained reliably?
5. How can we make various characterizations relevant? How do we do this easily without destroying the cavity or causing it to be re-processed?

General issues

- What is useful, and what is immediately applicable?
  - **Projects in planning phase: 3 year window (or so)**
  - **HEP stewardship of accelerator technology: long term capability**
- Making coupons relevant to cavities
  - **Need coupon Q vs E**
    - **Mushroom cavities at Cornell, TAMU, Stanford, Scanned-probe Q vs E**
  - **Need cavity spectroscopy (topography is now available!)**
    - **Cut-outs from single cells**
  - **Need coupon forming and chemical processing same as cavity forming and processing**
    - **Coupons are generally annealed, cavities are generally cold-worked before welding**
- Maximize useful cavities, minimize cost
  - **Prevent defects, Repair known defects**
  - **Processing at what cost? Future: CBP or BCP, with final EP**
    - **CBP or BCP to prescribed roughness to set up EP, EP at 25 C or colder**

Session 1.
Materials issues from cavity tests

- 1.3 GHz paradigm: maximize gradient at $Q \sim 10^{10}$
  - Several 9-cell cavities being processed to >40 MV/m; performance depends on facility
  - Many 1-cell cavities being processed to >40 MV/m; this is now expected from all facilities
  - Quenches at lower gradients remain; they often occur at specific locations and are correlated with visible defects (pits, stains, etc)
    - **Investigate origin of defects to prevent them**
    - **Reduce processing errors**
  - Field Emission addressed with HPR; system issue, model it, develop remediation or preventative measures
    - **Is there a field-emission-proof surface? Polymeric films?**
- 650 MHz paradigm: reduce R_s
  - 3 times more niobium; opportunity for films?
  - Spokes too
  - Modest gradient: different processing paradigm? Probably not pushing the technology, just pushing the cost issues
  - Need to update thermal conductivity and R_s data and R_{BCS} (T), Q(E) at different temperatures
  - Need non-linear BCS model of surface resistance

Session 1. Materials issues, cavity tests - 2

- Topography might not be the chief materials challenge
  - 40 to 40,000 nm, all sizes and shapes... does this depend on frequency?
  - Tumbled cavity with awful surface and 40 MV/m
  - FNAL will be cutting out samples from cavity quench locations and control locations for spectroscopy analyses
- Cavity baking might consider 2 steps: removal of bulk hydrogen, and removal of *surface* hydrogen
  - Both are accomplished at 800 °C; with other changes (Rv, Rx) the combination leads to higher gradient
  - Surface hydrogen – New implications for hydrogen-vacancy and vacancy-dislocation interactions mean new implications for 120 °C bake, too
- How, or where, pits cause quench might be more complex than we have thought
  - By admitting flux, might the quench location move elsewhere? Test with different cooling procedures