ACCELERATOR SEMINAR

"HIGH FIELD Q DROP in SUPERCONDUCTING Nb RF CAVITIES: caused by MAGNETIC or ELECTRIC RF FIELDS?"

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The major obstacle of reaching accelerating gradients above 20MV/m, i.e. maximal surface fields above 40MV/m, needed for ILC or FELs has been phrased and summarized first as field emission free, exponential, high field Q drop (HFQ) by Bernard Visentin 1999. By improved surface quality and by UHV baking at about 120°C reducing, e.g. dislocation- and grain boundary- densities, HFQ shifts to higher fields and HFQ hot spots shift toward the equator of accelerator cavities. Experimentally, HFQ seems weaker at X band as compared to L- and S-band and HFQ seems independent of the temperature $T \lesssim 2.17K$. Experimentally, HFQ seems neither to be related to grain boundaries, nor to Abrikosov fluxon penetration, nor to rf flux losses where all those superconducting state related mechanisms increase like ω^2 with frequency and increase with T. In contrast HFQ, initiated by ITE as source term is T independent and increases like ω dominated by its loss term, as in field emission loading. Dielectric interface rf losses $R^E(E)$ are usually small as compared to magnetic rf shielding current losses R^H. But for Nb conduction electrons $n_C=6\cdot 10^{22}/cm^3$ are adjacent to the high density of localized states $n_L(z_L)\lesssim 10^{20}/cm^3$ in Nb_2O_5 with strong interface tunnel exchange (ITE). By opening of the superconducting energy gap Δ in $n_C(|\varepsilon|<\Delta)$ ITE dies out for E<1MV/m for $n_L(z_L,|\varepsilon|<\Delta)$ yielding electronic two level systems (ETLS) observable, e.g. as dielectric interface losses, excess noise or surface magnetisms in qbits saturating for $E \ll 1kV/m$ and $T \ll 2K$. For E>1MV/m the energy gain $ez_LE(t)$ for $z_L \gtrsim 1nm$ lift $n_L(z_L,\varepsilon\lesssim -\Delta)$- up to $n_L(z_L,\varepsilon\gtrsim\Delta)$- states ITE coupled to empty $n_C(z,\varepsilon\gtrsim\Delta_{ave})$ states breaking so Cooper pairs where the states $n_C(z,\varepsilon\lesssim\Delta)$ are easily saturated causing negligible rf losses above 10V/m. As HFQ source term only some of those broken pairs are able to escape into delocalized states $n_C(|\varepsilon|\gtrsim\Delta_{ave})$ dissipating the gained energy >2Δ inside the metallic Nb creating hot quasiparticles absorbing rf $\propto B^2R_{BCS}(T)$ dominating as HFQ loss term the exponential, field emission free, high field Q drop (HFQ) above 10 – 30 MV/m. Heat map measurements in L-band TM_{010} cavities, showed *firstly*, that hot spots with their $\Delta T_{ou}(E,r)$ and $R^E(E)$ increases can be quantitatively described by ITE with tunnel properties of Nb_2O_5 and one fit parameter b; *secondly*, classic rf absorption and quasi particle transport have to be substituted by processes where excitations have long mean free paths accompanied by deviations from thermal equilibrium, especially at the metallic NbO_x/Nb interface.

In summary, the combined action of $R^E(E)$ and of $R^H(H)$ defines the degradation of Q(E,H) with increasing fields of superconducting Nb cavities.,

Friday, August 13, 2010
11:00 a.m. – 12:00 p.m.
CEBAF Center, Room L102/104

Coffee before seminar beginning at 10:30 a.m.

Jefferson Lab

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