Saclay Laboratory Report

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R&D activities on RF Superconductivity have continued at Saclay during the last two years. For this conference, an important effort has been made to update a picture of the laboratory latest results, under the form of 19 contributed papers. In the following, a mere "table of contents" of these contributed papers will be found.

High gradients and field emission

Research on field emission has been in progress, with the double objective of gaining understanding on its mechanisms in RF superconducting cavities, and of finding treatments to cure it. Results have been published in various reviews (ref. 1). RF field emission has been investigated, using a specially designed reentrant cavity operating at room temperature. Among the various results, let us cite :

-RF processing is believed to occcur via a thermo-mechanical instability of the emitting sites, leading to their destruction. We tried to disentangle the respective roles of thermal and mechanical effects by performing RF processing on various metal surfaces, with different melting points and tensile strengths (Poster W42);

-An important parameter which determines the thermal behaviour of particulate emitting sites is the thermal contact resistance between the particle and the substrate. This resistance was measured by irradiating a particle with an electron beam (Poster W2);

-Adsorbed atoms can modify field emission. We have shown that their removal results in a very stable and reproducible field emission, both in DC and RF regimes (Poster W40);
-The RF field can be used to clean the surface from its particulate contaminants. The interplay between adherence forces and electromagnetic forces acting on the particles has been studied experimentally (Poster W1);

-Particulate contaminants are prominent field emitters. Their behaviour was studied in RF regime with a reentrant cavity allowing a visual observation of the luminous phenomena inside the cavity. The main outcome of this study is that insulating particles, basically inactive in DC regime, emit light and electrons in RF regime (Poster W41);

-Particulate contamination in cavities or other vacuum systems was studied with a particle counter operating in vacuum. We tried to identify the most contaminating steps during cavity assembly and vacuum operation (Poster W12).

Superconductor characterization

A dielectric resonator has been developed, enabling the fast measurement of the surface resistance of superconducting samples. Even though it is less precise than a usual cavity, its simplicity, and its ability to measure samples of any size or shape make this device a valuable tool for the fast characterisation of new superconductors. It has been used extensively to revisit the Q-disease of niobium contaminated by hydrogen. A few new results have been added, suggesting that a heat treatment at 300°C might cure the disease (Poster T1).

A new method for measuring the RRR-value of Niobium has been developed. Using eddy currents induced in the material, it is now possible to determine non-destructively the local RRR value of the superconductor. Application of this principle to the mapping of the RRR-value of a cavity is underway (Poster T3).

Niobium properties

The mechanical properties of niobium have been investigated, in order to prepare the hydroforming of seamless cavities. The influence of annealing and recrystallyzation has been extensively studied (Poster T10).

Niobium postpurification by heat treatment and titanium gettering seems to be indispensable if very high cavity performance is sought for. Saclay has developed a new heat treatment cycle which treats sequentially the Titanium sublimation and the impurity diffusion (ref. 2). A considerable improvement of the material RRR-value has been obtained in this fashion (Poster T24).
During niobium postpurification, Titanium acts as a getter, but may also behave as an impurity if Titanium atoms diffuse deep into the material. Preferential diffusion and segregation of Titanium in the grain boundaries of the niobium matrix has been discovered, using the Saclay nuclear microprobe (Poster T23).

The thermal conductivity of niobium and the Kapitza resistance at the niobium-helium interface are two quantities which determine the thermal behaviour of a superconducting cavity. These two quantities have been carefully measured on a variety of samples. Semi empirical parametrisations of the thermal conductivity of Niobium (ref. 3, Poster T27) and of the Nb-HeII interface (ref. 4, Poster T26) have been extracted from these data.
Using these updated ingredients, the thermal behaviour of superconducting cavities has been entirely revisited by Henri Safa. He develops a new formalism to treat analytically the case of a defect on a superconducting surface (Poster W14).

Thin superconducting films

R&D on thin superconducting films has been continued. A collaboration between CEA and CERN has produced 1.5 GHz Nb/Cu cavities with an exceptionnally low surface resistance (Poster W26).
NbTiN/Cu cavities have also been fabricated at Saclay with somewhat less encouraging results. The substrate seems to play a crucial role on the adherence of the film as well as on its surface resistance, but this role is not yet mastered (Poster W34).

Accelerator issues

The R&D activity decribed above is basically independent of any considered application. However, the main superconducting accelerators presently envisaged at Saclay are the e^+e^- collider TESLA, and the electron linac ELFE. Participation of Saclay-Orsay to the TESLA collaboration includes the horizontal test cryostat CHECHIA (Poster W23), the design of HOM and main couplers (Poster T35), and the design and fabrication of the n° 1 injector (Poster T32).

The Saclay laboratory is also in charge of the operation of the superconducting linac booster, producing heavy ion beams for nuclear physics. The linac was stopped last year, despite its excellent operation, because of the lack of demand from the nuclear physics community. Sadly enough, Bernard Cauvin, one of the fathers of this accelerator, and one of the most prominent members of the Saclay RF superconductvity team, left us at the same time. The Saclay contributions to this workshop will be dedicated to his memory.

References

1 B. Bonin, Vacuum 46 (1995) 907
M. Jimenez et al., J. Phys. D : Applied Phys. 26 (1993) 1503
M. Jimenez et al., J. Phys. D : Applied Phys. 27 (1994) 1038
J. Tan et al., J. Phys. D : Applied Phys. 27 (1994) 2644
B. Bonin, "Field emission in RF cavities", CERN course on Particle Accelerators, Hamburg, May 1995

2 H. Safa et al., CEA DAPNIA SEA 95 03, to be published inJournal of Alloys and Compounds (1996)

3 F. Koechlin and B. Bonin, submitted to Superc. Sci. Technol.(1995)

4 A. Boucheffa, Thesis, Orsay University (1995)