VERY HIGH FIELD QUASI-PERMANENT HIGH-TEMPERATURE SUPERCONDUCTING MAGNETS WITH LOW CREEP

J. Liu, R. Weinstein, Y. Ren and R.-P. Sawh
Institute for Beam Particle Dynamics and Texas Center for Superconductivity, University of Houston, Houston, Texas 77204-5506

V. Obot
Department of Mathematics, Texas Southern University, Houston, Texas 77004

C.C. Foster
Indiana University Cyclotron Facility, Bloomington, Indiana 47408

As part of an ongoing effort to develop and understand high-temperature superconductors (HTS), small quasi-crystal tiles (2 cm in diameter and 0.32 to 0.8 cm thick) of $Y_{1.7}Ba_2Cu_3O_{7-\delta}Pt_{0.01}$ (Y123) have been produced at the University of Houston, irradiated with 200-MeV protons at the Indiana University Cyclotron Facility to increase the maximum trappable field by the introduction of pinning centers, combined to form mini-magnets of four tiles, and activated at the NSF National High Magnetic Field Laboratory in Tallahasse. World-record trapped magnetic fields have been produced in this way and procedures developed that reduce the slow decay of the trapped field, creep, to practically zero.

In the early 1970's, persistent fields in low temperature superconductors were studied at Stanford. Record fields of 2.3 T were trapped at 4 K.[1] We have studied trapped-field magnets using the newer high temperature superconductors (HTS).[2–10] A variety of techniques have been used to produce materials with increased maximum trappable fields, $B_{t,max}$.[11] Also operation at lower temperatures increases $B_{t,max}$.[11] An early generation of these tiles produced in 1993 and 1994, trapped 4.0 T at 64.5 K,[9] and 7.0 T at 55 K,[8] and eclipsed the record field observed at Stanford 17 years earlier.

Progress has been rapid in the last year. A mini-magnet fabricated from four single-grained tiles of Y123 grown by top-seeded melt texturing and irradiation by 200-MeV protons to a fluence of about 2×10^{16} p/cm^2 was studied using an applied field, B_A, of 13 T at the NHMFL. The mini-magnet was cooled to 54 K. B_A was reduced to zero in 83 min, at which time the trapped field, B_t, was 8.34 T, a record field for a permanent magnet. Cooling the Y123 after B_A reached zero was found to reduce creep greatly, by a factor of 197, as a result of post activation cooling by 4 K. These results were reported in June 21, 1995.[11]

In recent studies performed in June, 1995, using tiles irradiated with 200-MeV protons at IUCF in late February, 1995, a 10.1 T field was trapped at about 42 K. This field is

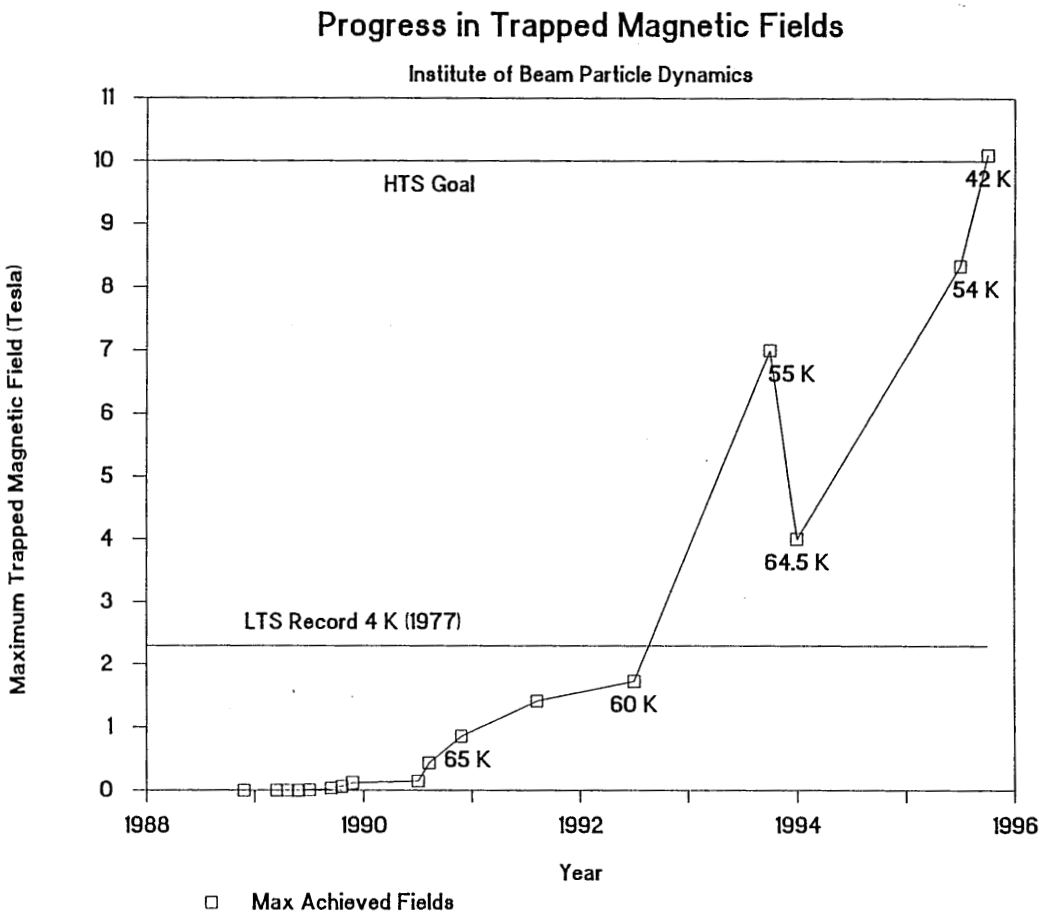

Figure 1. Maximum trapped magnetic fields achieved by Y123 samples produced by the Institute of Beam Particle Dynamics at the University of Houston as a function of time. While the samples are labelled by the temperature at which the fields were observed, the improvement in performance shown reflects a variety of improvements in fabrication techniques and the use of radiation exposure to introduce pinning centers. The 1977 record for low temperature superconductors (LTS) of 2.3 T and the goal for high temperature superconductors (HTS) of 10 T are plotted for comparison.

a world record for a permanent magnet ingot made of any material, and operated at any temperature.[12] It is six times higher than fields achieved by electromagnets.

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