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Invited Talk- IT: Discoveries of New Superconductors – A Golden Touch

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Content :

Kamerlingh Onnes's dream of using superconductors for high field magnets came true in the Golden Jubilee year of its discovery. Two superconductors of great importance, namely, Nb-Ti alloy and A-15 Nb3Sn were discovered in 1961. Nb-Ti cables with a current carrying capacity > 12 kA (LHC) and with low ac losses were produced by reducing the filament dia. to 5-6 μm and cladding the filaments with Nb-barrier. Similarly CICC Nb3Sn cables produced by DT (distributive tin) techniques carry a current of 68 kA in the toroidal coils of the ITER. Transition temperature (Tc) however remained confined to ~ 23 K (Nb3Ge) until superconductivity was discovered at 35 K in La2CuO4 doped optimally with Ba or Sr in 1986. What followed soon after was unprecedented. Cuprates with Tc above 77 K were discovered one after another in quick succession. High Tc, = 90 K in Y1Ba2Cu3O7, Tc = 110 K in Bi(Pb)2Sr2Ca2Cu3Oy, Tc = 135 K in Tl2Ba2Ca2Cu3Oy and HgBa2Ca2Cu3Oy compounds were reported. Bi-2223 has been in use for current leads in cryo-free magnet systems. In recent times (RE-Y)-123 coated tape conductors using sophisticated film deposition techniques have emerged as the best material available for high field production if only operated below 60 K. Jc = 15 x 106 A.□□–2 [30 K, 2.5 T(B וו c)] was achieved with 25 mol % Zr doping at Houston. A lift factor of 6 at [30 K, 2.5 T(B וו c)] was achieved by optmizing (Gd+Y), (Ba+Zr) and Cu compositions

After a lull for about a decade, nature surprised us yet again when a new variety of superconductors were discovered in 2001 onwards. MgB2 (Tc = 39 K) discovered in 2001 has come of age and MgB2 conductors are used in magnets operating at 20 K (cooled by the cryocooler) and producing moderate magnetic field. 3 T MRI cryocooled magnets using MgB2 may hit the market sooner than expected. It appeared as though the scientists got the Mida's touch. Magnetic materials, such as iron and cobalt considered, for long, to be the enemies of superconductivity started turning superconductors. Hosono at TIT reported in 2008 superconductivity in iron oxy-pnictides FeAs□0.89 □0.11 under high pressure at 43 K. Same year, a Chinese Groups reported a Tc = 55 K for F-doped SmFeAs□(1–□) □□ compound under ambient pressure. Unlike Cuprates, undoped iron compounds are metallic and have a layered structure. MO or MF layers are insulating while the FePn or FeCh layers conducting. Current and field anisotropies too are less severe. High Quality Co-doped epitaxial Ba(Fe,Co)2□□2 (122) films had Tc = 25.5 K for x = 0.075 in

Ba[□□(1– □)□□□]2 □□2 target. P-doped Ba-122:P films have higher Hc2 and have the potential of high Jc through effective pinning. Improved Tc = 21.5 K, ΔT = 1.1 K and Jc = 4 x 106 A□□–1) (4 K, self field) have been achieved. High purity targets of Ba□□2 (□□0.6 □0.4)2 yields films with Jc = 1x106 A □m–2 (10 K, 1 T). Addition of 3 mole% Barium Zirconate (BaZr□3) nanoparticles in the Ba-122:P epitaxial films results in an increase of Jc in magnetic field by a factor of 2.6. PIT technique too has yielded high Jc in Ba-122:P = 9.0 x 104 Acm-1 (4.2 K, 10 T). Jc decreases very little with field up to 28 T and exceeds that of Nb3Sn beyond 20 T at 4.2 K.

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