Pinning performance of a ternary LRE-123 single crystal

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We present data on the pinning performance of a ternary single crystal of $(Nd,Eu,Gd)Ba_2Cu_3O_y$ in temperature range 65 K to 90 K. The crystal exhibited a $T_{c,onset}$ of 93.75 K and a transition width $\Delta T \approx 1.2$ K. Critical currents, pinning forces, and logarithmic relaxation rates were determined on the basis of magnetic hysteresis loops (MHLs) measured by a vibrating sample magnetometer up to 9 Tesla with field sweep rates from 0.7 to 0.06 T/min. At 65 K, the MHL featured a rather strong second peak, which gives evidence of a very well set amount of point-like pinning disorder due to LRE/Ba solid solution clusters (LRE=Nd,Eu,Gd(,Sm)). The top of the second peak was slightly deformed by the twin plane channeling effect. The central peak height was about half of that of the second peak, but well resolved and rather slim. The effect of twin plane channeling continuously decreased but persisted with increasing temperature. Simultaneously, the height ratio of the second peak to the central peak decreased in contrast to the behavior of Y-123 or Dy-123 twin-free single crystals, but in accord with $LRE\text{-}Ba_2Cu_3O_y$ melt-textured materials of a similar composition. The critical current density at 77 K achieved 52 and 62 kA/cm^2 at zero field and at the second peak position of 2.2 Tesla, respectively. None of the $J(B)F(B)$ curves ($F=BJ$) scaled at least at a narrow temperature range. This indicates a complicated, temperature-dependent pinning structure. The field dependence of the dynamic logarithmic relaxation rate, $Q(B)=\mathrm{dln}J/\mathrm{dln}(\mathrm{d}B/\mathrm{d}t)$, determined from two MHLs measured with slightly different field sweep rates was in very good accord with that calculated from the logarithmic derivative of one of the MHLs, $\chi_E=\mathrm{dln}M/\mathrm{dln}B$, using the Perkins' formula $Q=g_E(1-\chi_E)$, where g_E represents Q value at the second peak position. The $Q(B)$ curves exhibited three linear parts, observed also previously in other twinned samples, evidently due to twin plane channeling effect.