High current stability and sharp $E(J)$ curves in high-J_c polycrystalline MgB_2 films

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We have investigated the pinning of vortices in high-J_c films of polycrystalline MgB_2, through study of the dependence of current density J on electric field E using both magnetic and transport methods. Precursor films of amorphous boron, previously deposited on sapphire substrates, were converted to 0.6 μm thick MgB_2 by post-annealing in the presence of Mg vapor at 890 °C for 2 h. In magnetic studies, a SQUID magnetometer was used conventionally to determine the induced current density by the Bean model. An unconventional approach was used to monitor the decay of J with time t: the sample was moved quickly upward into a high field region in the center of the pickup coils, where it remained fixed in position while the SQUID feedback voltage $\propto J$ was measured versus time. This has several technical advantages that will be discussed. The resulting logarithmic decay rates $S = -d\ln(J)/d\ln(t)$ was found to be very low in the H-T phase space away from the irreversibility line. Complementary 4-probe transport studies of the electric field-current density are analyzed as a power law dependence of the form $E \propto J^n$, where the exponent $n = (1+S)/S$. Effective values for n approach and sometimes significantly exceed 100. These results will be contrasted with the much more rapid decay typically observed in high-T_c and some conventional superconductors.

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