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Exploring the limits of critical currents in superconductors

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Mechanisms, which determine the ultimate limit of the critical current density $J_c(T, B)$ in superconductors are discussed. The talk is mostly focused on the extreme strong pinning limit of highly deformed vortex segments, the role of anisotropy, current-blocking effects of pinning centers and grain boundaries, thermal fluctuations of vortices in high-T_c superconductors. In particular, the design of optimum pinning nanostructures, which produce the maximum J_c is addressed. The results are applied to YBCO thick-film coated conductors with insulating nanoprecipitates, for which several groups have reported very high J_c values, up to 12-20 % of the depairing current density. Requirements for a putative room-temperature superconductor to be useful in high-field applications are discussed.