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.