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Unique defect structure and advantageous vortex pinning properties in $CaKFe_4As_4$

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The enhancement of critical current density (J_c) is one of the key issues towards superconductivity applications. After the discovery of iron-based superconductors (IBSs), which are considered as candidate materials for high-field applications, high J_c values have been achieved by various techniques to introduce artificial pinning centers, while a further improvement of J_c is desired. Among various IBSs, 122 materials such as $Ba_{1-x}K_xFe_2As_2$ have been intensively studied owing to their small anisotropy. Meanwhile, recent studies demonstrated the high application potentiality of $CaKFe_4As_4$ (CaK1144) [1-3]. Here, we report unprecedented vortex pinning properties in the CaK1144 system arising from the inherent defect structure. Scanning transmission electron microscopy (STEM) revealed the existence of nanoscale intergrowths of the $CaFe_2As_2$ phase, which is unique to CaK1144 formed as a line compound. The J_c properties in CaK1144 are found to be distinct from other IBSs characterized by a significant anisotropy with respect to the magnetic field orientation as well as a novel pinning mechanism significantly enhanced with increasing temperature. We propose a comprehensive explanation of the J_c properties based on the unique intergrowths acting as pinning centers.

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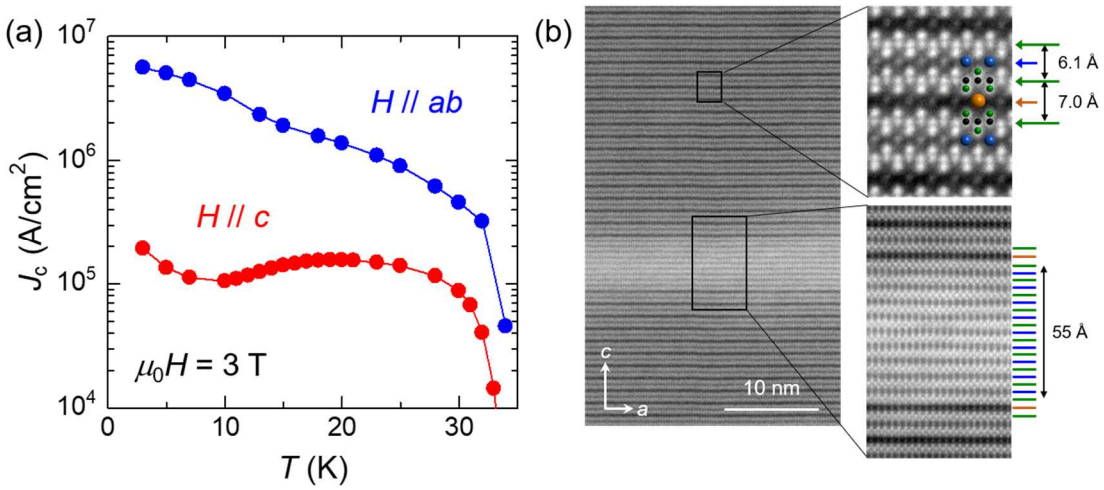

Fig. (a) Temperature dependence of J_c of CaK1144 single crystal under 3 T for H // c (red) and ab (blue), (b) STEM images around CaK1144 matrix and Ca122 intergrowth.

Keywords: Iron-based superconductors, CaKFe4As4, Critical current density, Defect structure