Thin film growth of $BaFe_2(As,P)_2$ and NdFeAs(O,F) on single-crystal and IBAD-MgO buffered substrates

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Iron based superconductors show high upper critical fields with relatively low anisotropies at low temperatures, features that are advantageous for high-field applications. Among the known iron based superconductors, *Ln*FeAs(O,F) (*Ln*=lanthanide) has the highest critical temperature (T_c) of about 56 K, but studies on critical current density (J_c) are still limited because of the difficulty in crystal growth, including thin films. Here we present high field transport properties of NdFeAs(O,F) epitaxial thin films grown by molecular beam epitaxy (MBE). While our earlier thin films showed a somewhat lower J_c, a large value of 3.3 MA/cm^2 was recorded at 4.2 K, self-field, after improving the crystalline quality by increasing the growth temperature. High field measurements carried out with a dc field showed that J_c was larger than 10^6 A/cm^2 up to 35 T for $H \parallel ab$. The dependence of J_c on the field orientation angle suggests that *c*-axis correlated pinning is absent, and the mass anisotropy γ evaluated from the Blatter scaling is 3 at 4.2 K, which is close to the values reported for LaFeAs(O,F) thin films. We also prepared NdFeAs(O,F) on IBAD-MgO/Y_2O_3/Hastelloy substrates that resulted in highly biaxial textured thin films. TEM observation revealed a clean interface between NdFeAs(O,F) and the MgO template. J_c of these thin films on IBAD buffered metal tapes was 20 times higher than PIT-processed SmFeAs(O,F) wires.

We have also grown thin films of $BaFe_2(As,P)_2$ with T_c around 30 K, which is the second highest T_c among the Ba-122 families. We found an interesting correlation between J_c and the Fe/Ba composition ratio, and observed a very large J_c that exceeded 10^7 A/cm^2 at 4.2 K when the thin film was rich in Fe. Moreover, J_c across a [001]-tilted grain boundary recorded 10^6 A/cm^2 at 4.0 K even at a large misorientation angle of 24°, implying that the necessary condition of in-plane alignment would be moderate compared to cuprate superconductors. In-field resistivity measurements showed a clear shift of T_c for both principal crystallographic directions with a small transition width, similarly to the other Ba-122 systems, and γ was close to 1.2 at 4.2 K. Thin films of $BaFe_2(As,P)_2$ on IBAD-MgO buffered metal substrate were also grown, the properties of which is now under investigation and will be reported.

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