Probing the Effect of Interface on Pinning Efficiency of 1D $BaZrO_3$ and $BaHfO_3$ Artificial Pinning Centers in $YBa_2Cu_3O_{7-x}$ Thin Films

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Abstract **– C-axis aligned one-dimensional artificial pinning centers (1D APCs) have proven to provide an effective solution to reduce the magnetic field (H) orientation-dependence of the critical current density, J_c, an issue stemming from the layered structure of $YBa_2Cu_3O_{7-x}$ (YBCO). A fundamental question arises as to what determines the pinning efficiencies of a 1D APC? In order to shed light on this question, 1D APCs of $BaZrO_3$ (BZO) and $BaHfO_3$ (BHO) of comparable lateral dimensions (5-6 nm) were selected in our recent studies on the 1D APC/YBCO interface and its impact on the pinning efficiency of these 1D APCs in the 1D APC/YBCO nanocomposite films with APC doping levels varied in the range of 2-6 vol.%. We have found that the BZO/RE-123 interface is semi-coherent with a large number of dislocations consistent with prior reports. In contrast, the BHO/RE-123 interface remains coherent even at high BHO doping levels. This difference was found to have a profound effect on the pining efficiency of BZO and BHO 1D APCs evaluated quantitatively from the maximum pinning force density (F_{pmax}) at H_{max} (H//c) and the ratio between the H_{max} and the accommodation field H* estimated from the TEM characterization of the 1D APC concentration. Importantly, a record high $F_{p,max}$~183.0 GNm^{-3} at H_{max}>9.0 T (instrument limit) and 65 K was obtained in BHO/YBCO nanocomposites, which is significantly higher than the $F_{p,max}$~73.0 GNm^{-3} at H_{max}=5.0 T in its BZO/YBCO counterpart. Moreover, the H_{max}/H* ratio in both cases decreases monotonically with APC doping. However, it is up to 2.5-3.5 in the BHO/YBCO case in contrast to the maximum of 0.6-0.7 in the BZO/YBCO case. This result reveals the critical effect of APC/YBCO interfaces on the pinning efficiency of 1D APCs.**

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Keywords (Index Terms) **– YBCO nanocomposite film, artificial pinning center, vortex pinning efficiency, coherent interface.**

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