Pressure effect on ferromagnetism and exchange bias in Ru-doped manganites

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Pressure effect on magnetic state and exchange bias (EB) in phase-separated ferromagnetic/antiferromagnetic (FM/AFM) $CaMn_{1-x}Ru_xO_3$ ($0.06 \leq x \leq 0.15$) and $Bi_{0.4}Ca_{0.6}Mn_{1-x}Ru_xO_3$ ($x = 0.1$, 0.2) manganites was studied under a pressure up to 11 kbar. For both manganites, complex pressure and Ru-doping effects on EB and coercive fields may be explained with a model of size-variable (depending on Ru content and pressure) nanoscale FM droplets embedded in an AFM matrix. For $CaMn_{1-x}Ru_xO_3$, the observed enhancement of EB with increasing pressure is attributed to the reduction in the FM cluster size, evidenced by both pressure dependence of spontaneous FM moment and EB field dependence upon cooling field. In contrast, for $Bi_{0.4}Ca_{0.6}Mn_{1-x}Ru_xO_3$, both Ru-doping and external pressure act similarly, leading to a growth of the FM clusters and consequently to a suppression of the EB. The results show that for phase-separated FM/AFM manganites the EB effect may be smoothly controlled by pressure.