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$(Nd_{0.75}Na_{0.25})_{1-x}(Nd_{0.5}Ca_{0.5})_xMnO_3$中电荷有序稳定性关系的超声研究

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摘要 系统研究了$(Nd_{0.75}Na_{0.25})_{1-x}(Nd_{0.5}Ca_{0.5})_xMnO_3$($x$=0、0.25、0.5、0.75、1)单相多晶样品在低温下的电磁输运性质和超声特性. 电阻和磁化率的测量表明所有样品均发生了电荷有序相变. 随着钠掺杂量的增加, 电荷有序相变温度(T_{co})向低温移动同时低温端磁化强度增大, 并且电荷有序态趋向于不稳定和短程化. 超声纵波声速从室温开始随着温度的降低逐渐减小, 在T_{co}之后声速急剧硬化. 这种超声异常表明体系中存在着强烈的电-声子相互作用, 该电-声子耦合来源于Mn^{3+}的Jahn-Teller效应. 对纵波模量软化部分的拟合显示, 随着钠的掺入, 反映Jahn-Teller效应大小的Jahn-Teller耦合能E_{JT}变小. 分析认为电荷失配效应是导致电荷有序被抑制和Jahn-Teller耦合能E_{JT}变小的主要因素.

关键词 超声声速 电荷有序态 电荷失配效应 Jahn-Teller 效应

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Ultrasonic Study of the Stability of the Charge Ordering in $(Nd_{0.75}Na_{0.25})_{1-x}(Nd_{0.5}Ca_{0.5})_xMnO_3$

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Abstract The electrical resistivity, magnetization, and ultrasonic velocity were investigated systematically in polycrystalline $(Nd_{0.75}Na_{0.25})_{1-x}(Nd_{0.5}Ca_{0.5})_xMnO_3$ (x=0, 0.25, 0.5, 0.75, 1). A charge ordering transition was observed in all samples through resistivity and magnetization measurements. With increasing Na content, the charge ordering transition temperature (T_{co}) shifts to lower temperature, the magnetization of the system is strengthened and charge ordering becomes more unstable and short-ranged. It is found that the longitudinal sound velocity shows a dramatic softening and stiffening around T_{co}. The ultrasonic anomaly near T_{co} indicates the existence of strong electron-phonon interaction, which originates from Jahn-Teller effect of Mn^{3+}. By fitting the experimental longitudinal modulus above T_{co} with the cooperative Jahn-Teller theory, one can establish that the Jahn-Teller coupling energy E_{JT} decreases with increasing Na content. The analysis of experimental results suggests that the charge mismatch should be the main reason for the suppression of the charge ordering and the weakening of cooperative Jahn-Teller effect.

Key words ultrasonic velocity charge ordering charge mismatch effect Jahn-Teller effect

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