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DISTINCTIVE FEATURES OF METAL/SUPERCONDUCTOR-INSULATOR TRANSITIONS IN DOPED La-BASED CUPRATES WITH LARGE-RADIUS IMPURITIES

In polar materials, lattice vibrations (acoustic and optical phonons) and hole carriers interacting with lattice defects (e.g., dopants or impurities) can be self-trapped near defects and in a defect-free deformable lattice. In the localization of charge carriers and metal/superconductor-insulator transitions in hole-doped cuprates, the role of large and small radius dopants (impurities), carrier-defect-lattice and carrier-lattice interactions is of more importance [1]. In doped La-based cuprates with small-radius impurities, metal-insulator transitions arising from two types interactions mentioned above will occur over a wide doping range from lightly doped to heavily doped states [2]. However, in doped La-based cuprates with large-radius dopants, it is not obvious which interactions will dominate and cause the metal/superconductor-insulator transitions [3].
In this work, we study the possibility of the localization of hole carriers and the distinctive features of the metal/superconductor-insulator transitions in doped La-based cuprates with large-radius dopants (impurities) within the single-carrier cuprate superconductor model. We show that when the value of the high-frequency dielectric constant ε∞ changes from 5 to 2.5 the new metal/superconductor-insulator transitions in doped cuprates La2−xSrxCuO4 (LSCO) and La2−xBaxCuO4 (LBCO) are caused by the strong hole-lattice interactions and polaronic effects and occur in a wide doping range from the lightly doped to strongly overdoped regime. We find that such metal/superconductor-insulator transitions depending on the values of ε∞ and η= ε∞/ ε0 (e.g., for ε∞ ≥2.5 and η≥0.02) and the types of charge ordering occur in these materials in the strongly overdoped regime (when the binding energy Ep of large polarons is increased significantly from 0.05 eV (at ε∞ =5) up to 0.2 eV (at ε∞ =2.5)), as observed experimentally in ARPES studies [4]. Our theoretical results for metal/superconductor-insulator transitions in doped La-based cuprates are in good agreement with the experimental findings.

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Section

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