Abstract

The doctoral dissertation is devoted to the study of the electronic structure of the following compounds: iron-based superconductors $Fe_{1.01}Te_{0.65}Se_{0.35}$ and $Fe_{1-y}M_yTe_{0.65}Se_{0.35}$ (M = Ni and Co); parent compound $CaFe_2As_2$ and $CaFe_{2-x}Co_xAs_2$ system, in which the substitution of cobalt in a place of iron induces superconductivity to; $LaAgSb_2$, for which a superconducting phase and a phase of charge density waves are observed; and superconducting $LaCuSb_2$. Measurements were carried out using the angle-resolved photoemission spectroscopy (ARPES) technique.

For the $Fe_{1.01}Te_{0.65}Se_{0.35}$ compound, the substitution of nickel or cobalt in place of iron results in suppression of superconductivity. We conducted research on the undoped compound and on $Fe_{0.97}Ni_{0.05}Te_{0.65}Se_{0.35}$, $Fe_{0.91}Ni_{0.11}Te_{0.65}Se_{0.35}$ and $Fe_{0.94}Co_{0.09}Te_{0.67}Se_{0.33}$. We observed the deformation of the band structure under the influence of doping and determined band shifts and changes in the volume of the Fermi surface. The electron part of the Fermi surface increases while the hole part disappears, which results in a change in its topology called the Lifshitz transition. We have shown that changes in the band structure cannot be understood as a simple Fermi energy shift, but as a deformation of the entire structure. Cobalt doping turned out to have a much greater effect on the band structure than nickel doping, with nickel doping having a greater impact on the transport properties of these compounds. This means that substituting iron with nickel leads to a greater scattering on impurities and greater correlation effects than substituting with cobalt. Moreover, we have shown that doping causes the Fermi surface nesting to disappear.

In the case of $CaFe_2As_2$, the substitution of cobalt in place of iron causes the appearance of superconductivity in the system and the transition from the antiferromagnetic phase with orthorhombic structure to the paramagnetic phase with tetragonal structure. We tested three samples: non-superconducting $CaFe_2As_2$ and superconducting $CaFe_{1.93}Co_{0.07}As_2$ and $CaFe_{1.85}Co_{0.15}As_2$. We observed two types of electronic structure, representing the antiferromagnetic phase for the undoped and lightly doped samples and the paramagnetic phase for the highly doped sample. As part of the antiferromagnetic phase, we did not observe any clear changes in the electronic structure. For both antiferromagnetic samples, we observed the existence of Dirac cones, it has not been reported so far for this compound. The electronic structure of the highly doped compound consists of bands that cross the Fermi level at points $\overline{\Gamma}$ and $\overline{X}$ forming quasi-two-dimensional cylinders on the Fermi surface. This structure is typical of most iron-based superconductors.

$LaAgSb_2$ is a Dirac semimetal where superconductivity and charge density waves are observed. The Fermi surface of this compound consists of four bands that form a diamond-like shape. We observed the presence of linear bands that form characteristic X-shaped crossings, nodal lines that extend in the Γ−Z direction and surface states suggesting that the studied surface corresponds to the termination of LaSb. It was not possible to confirm the existence of Dirac cones in the section $\overline{\Gamma}$–$\overline{M}$ which was suggested in earlier publications on that compound.

The structure of $LaCuSb_2$ also consists of linear bands that form X-shaped crossings. The existence of such bands indicates the potential presence of Dirac fermions in both systems. Therefore, we also observed the nodal lines in the direction Γ−Z. Comparison of the Fermi

surfaces of $LaCuSb_2$ and $LaAgSb_2$ indicates stronger nesting in the first compound. In $LaAgSb_2$ the lengths of the observed nesting vectors are different from the charge density wave modulation vectors; therefore they do not explain the existence of this phase.