SHUBNIKOV–DE HAAS OSCILLATIONS IN BI BICRYSTALS WITH SUPERCONDUCTING CRYSTALLITE INTERFACES OF TWISTING TYPE

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We report an investigation of quantum oscillations of ρ_{ij} (H) (Hall resistance and magnetoresistance) in Bi bicrystals with superconducting interface of twisting type, converted by magnetic field and/or a current in the normal state. Two groups of Bi bicrystals of twisting type were investigated: small crystallite disorientation angle (SDA) bicrystals with $\theta_1 < 9^0$ and large crystallite disorientation angle (LDA) bicrystals with $\theta_1 > 28^0$. SDA bicrystals had n-type of conductivity, LDA - p-type. Both groups of bicrystals are of a special interest because the CI exhibits superconducting properties (for some samples $T_{onset} \sim 16$ K). Two superconducting phases with $T_c \sim 8,4$ K, and $T_c \sim 4,3$ K have been observed at CI of LDA bicrystals.

On the other hand in SDA bicrystals only one superconducting phase is revealed at $T_c < 9$K and its superconducting parameters differ from values of LDA bicrystals. As a rule, in SDA bicrystals of bismuth there are shown quantum oscillations of ρ_{ij} (H) describing FS of crystallites (single crystalline blocks) and layer components of crystallite interface. The periods of quantum oscillations of ρ_{ij} (H) for crystallites of SDA bicrystals correspond to well-known electron and hole FS of single crystalline Bi. These data testify that the density of electrons and holes in crystallites of SDA bicrystals as well as in rhombohedral Bi is almost equal (n, p ~ 3 10^{23} m^{-3}). A number of new frequencies appear in large angular intervals of the magnetic field rotation. The angular dependences of the periods of quantum oscillations of ρ_{ij} (H) testify that in adjacent layers the structure of the electron Fermi surface is same as in crystallites (three electron pockets located in L points of the Brillouin zone and generated from the principal ones by ±120° rotations around the trigonal axis C_3).

The isoenergetic surfaces are less anisotropic (are flattened in the binary plane) and are much more in volume, than electronic pockets of crystallites. Quantum oscillations of ρ_{ij} (H) from the central layer of CI of the Bi bicrystals, connected with electron FS, were clearly observed at the magnetic field orientation along the internal surface plane, at its deviation by an angle > 10^0 they disappeared. Nevertheless, the obtained data testify that the density of electrons in CI central part is much more, than in the adjacent layers and makes ~ 1,5 10^{20} m^{-2}. Typical feature of superconducting LDA bicrystals is observation of the quantum oscillation of ρ_{ij} (H), connected with hole FS of the crystallite interface. Oscillations from electron FS of the CI and FS of the single crystalline blocks were not detected. The quantum oscillations of ρ_{ij} (H) in the adjacent layers of the CI of LDA bicrystals were registered in large angular intervals of magnetic field rotation. At the same time quantum oscillations from the CI central part were detected in the limited angular intervals (± 40° near H || C_3).

It is established that the elongation of FS in adjacent layers changes (FS is rotated in comparison with the ones in crystallites) and the hole ellipsoid of revolution in pure Bi turns to a deformed hole pocket with all three main cross-sectional areas different on size. The hole FS of the central part of LDA bicrystals in the investigated angular intervals of the magnetic field rotation is almost similar to FS of the adjacent layers and both considerably surpass in volume the hole isoenergetic surface of single crystalline Bi.