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Semiconductor with a Bulk and Two-Dimensional Conductivities: A New Element for Solid-State Devices

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It is known that many policrystalline semiconductors have grain boundaries quantum wells or barriers, which effect substantially on a sample conductivity. In this paper we present results of a theoretical and experimental study of electron transport phenomena in (HgCd)Te (MCT) policrystalline semiconductors, which apply broadly in solid-state devices. It is shown experimentally that electron channels appear at grain boundaries in MCT samples. The angle dependence of the magnetoresistivity oscillation amplitudes (Shubnikov de Haas oscillations) on the angle between a normal to 2D channel plane and a direction of a magnetic field demonstrates the two-dimensional nature of the grain boundaries conductivity. Thus, a sample has p- or n-type bulk conductivity and a two-dimensional conductivity along grain boundaries. A bulk conductivity can be reduced significantly at low temperatures (for p-type samples) or in a high magnetic field (for n-type samples). If a bulk conductivity is suppressed then we are left with only the conducting framework of 2D channels. The electron concentration and the the electron mobility in 2D channels are found to be $n = 10^{12} cm^{-2}$ and $\mu = 10^4\ cm^2/(V\ sec)$. It is shown that with decreasing of the sample thickness up to the value comparable with the average block size, one can reveal a size effect and anisotropy of the magnetoresistance with respect to the orientation of the magnetic field.