Realization of low contact resistance on MoS_2 field-effect transistors using low melting point metals and semimetals

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Abstract

Two-dimensional (2D) transition metal dichalcogenides (TMDs) are promising channel materials due to their ultrathin body, high mobility, and excellent electrostatic control. However, forming ohmic contact and achieving low contact resistance between TMDs and metals have always been challenging issues that tremendously limit the performance of 2D field-effect transistors (FETs). Using conventional thermal evaporation to deposit metal contacts could lead to the diffusion of metal atoms into the 2D TMD channel and may generate defects in the channel materials. The TMD channel materials may suffer from gap-state pinning effects, including defect-induced gap states (DIGS) and metal-induced gap states (MIGS), which will further cause Fermi-level pinning (FLP) and increase the Schottky barrier height (SBH) in the contact. In this work, we employ low melting point metal, indium (In), and semimetal, bismuth (Bi), as contact materials, which are argued to be promising candidates for reducing contact resistance. We observed significantly improved contact resistance and on-state current based on these approaches. Using the four-point measurement method, we can obtain the lowest contact resistances of 1.53 kΩ·μm at the 2D carrier density (n_{2D}) of 3.8×10^{12} cm^{-2} and 480 Ω·μm at n_{2D} of 3.4×10^{12} cm^{-2} for the Bi-contacted and In-contacted MoS_2 FET devices, respectively. Furthermore, we observe much improved on-current densities of 79.5 and 26.1 μA/μm and mobilities of 24.2 and 11.6 $cm^2/V \cdot s$ in Bi- and In-contacted MoS_2 FET devices, respectively. Finally, we will demonstrate the benefits of using In and Bi as contact materials for the materialization of high-performance 2D FETs which pave the way for the beyond-silicon electronics technology.

Keywords - Low Contact resistance, Semimetal, Indium, Bismuth