Supplementary Materials for

Title: Accurate change of carrier type within ultrathin $MoTe_2$ field-effect transistors with the time exposed to ambient air

Authors: S.P. Wang, R.J. Zhang, L. Zhang, L.F. Feng, J. Liu

Correspondence to: fengliefeng@tju.edu.cn; Jingliu_1112@tju.edu.cn

Supplementary Figure s1:

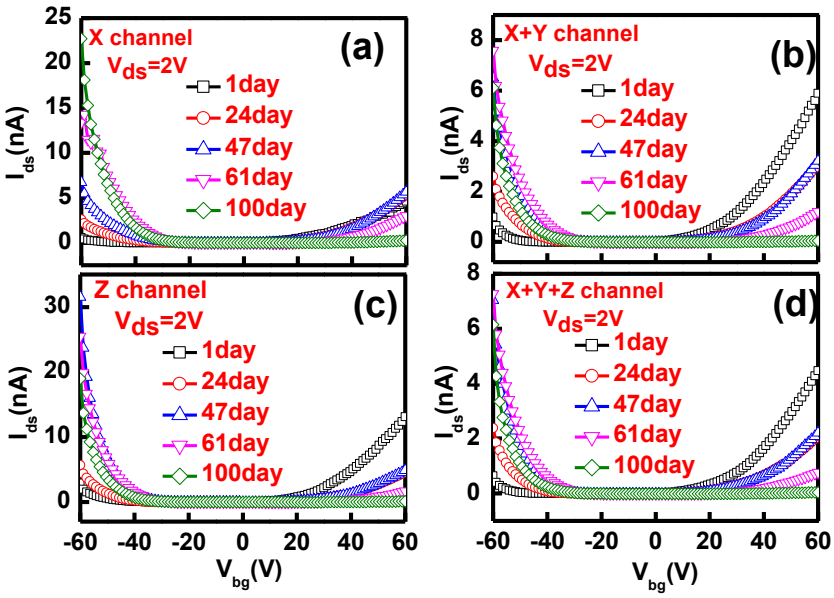

Figure s1. Variation of $MoTe_2$-FET transfer characteristic curves with different time exposing in ambient air, (a) X channel, (b) X+Y channel, (c) Z channel and (d) X+Y+Z channel

Different channels have a similar phenomenon, as shown in Figure s1. In the early stage of device preparation, the materials are bipolar and dominated by electronic conduction within different conductive channels. When the device is exposed to the air, the P and N types begin to switch. As the time goes on, the N type gradually weakens but the P type increases. Except the transfer characteristic curves of the 100th day of exposure to the air, at other days the I_{ds} under V_g=-60 V and +60 V have the same order of magnitude. At the 100th day, holes becomes the main type of carrier and electron conduction almost be completely suppressed. With the increase of channel length (from X or Z to X+Y or X+Y+Z), I_{ds} has a decreasing trend.

Supplementary Figure s2:

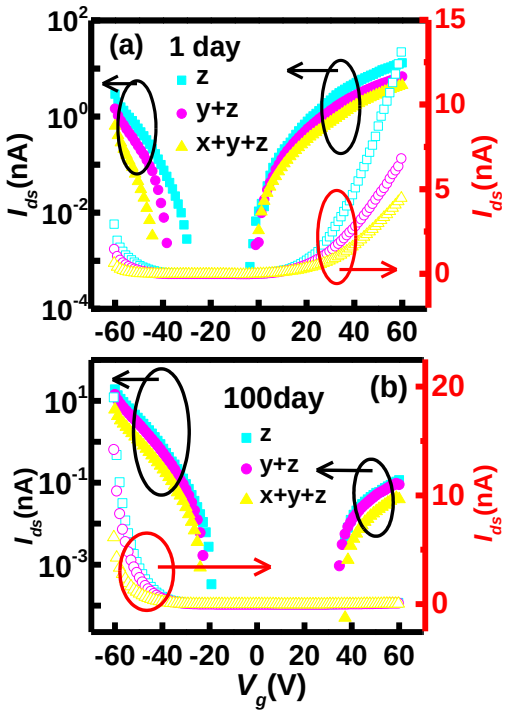

Figure s2. Comparison of the transfer characteristic curve of $MoTe_2$-FETs with different channels on the 1st and the 100th day.

Figure s2 shows the transfer characteristic of $MoTe_2$-FETs with different channels between the 1st and 100th days. After 100 days, in linear coordinates devices just display P type conductivity, N type is almost completely suppressed. In the semi logarithmic coordinate, although the material is still bipolar, under V_g=-60 V and +60 V the difference of the maximum current I_{ds} has more than 2 orders of magnitude. Moreover, at the 100th day the P type current has also increased comparing to the 1st day. These confirm that after a period of time in the air, the distribution of carrier types in the material has changed. Furthermore, at different days the V_{th} for both types shifts to the right of the coordinates. The subthreshold leakage current of the device is fairly small, close to the magnitude of pA. As the consequce, the gate leakage current will be domain. For our device, the gate leakage current is around~10^{-10}.