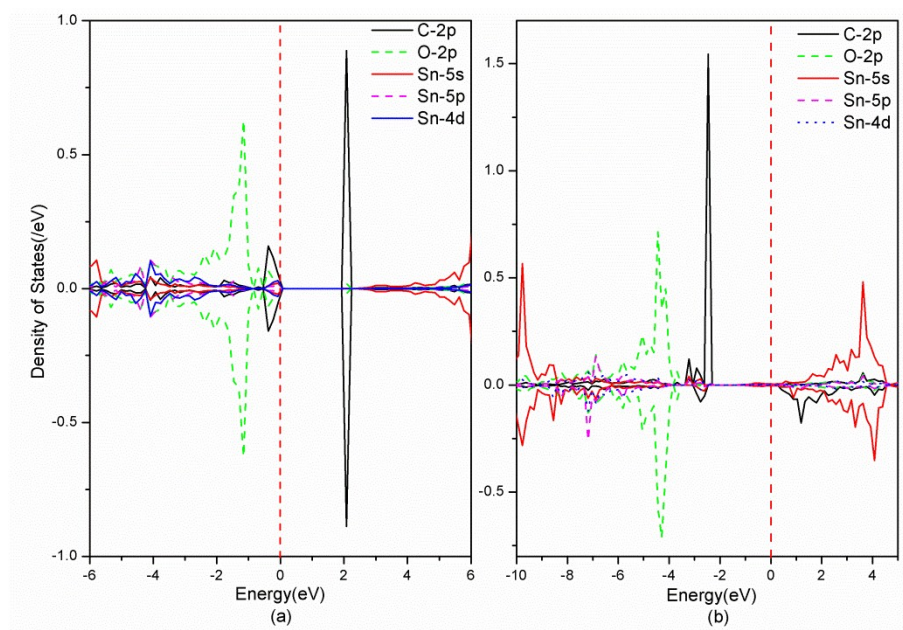# Supplementary materials

Figure S1. HSE06 function calculated PDOS of C_O defects in (a) neutral and (b) -2 charge state, respectively. The vertical red dashed line represents Fermi level.
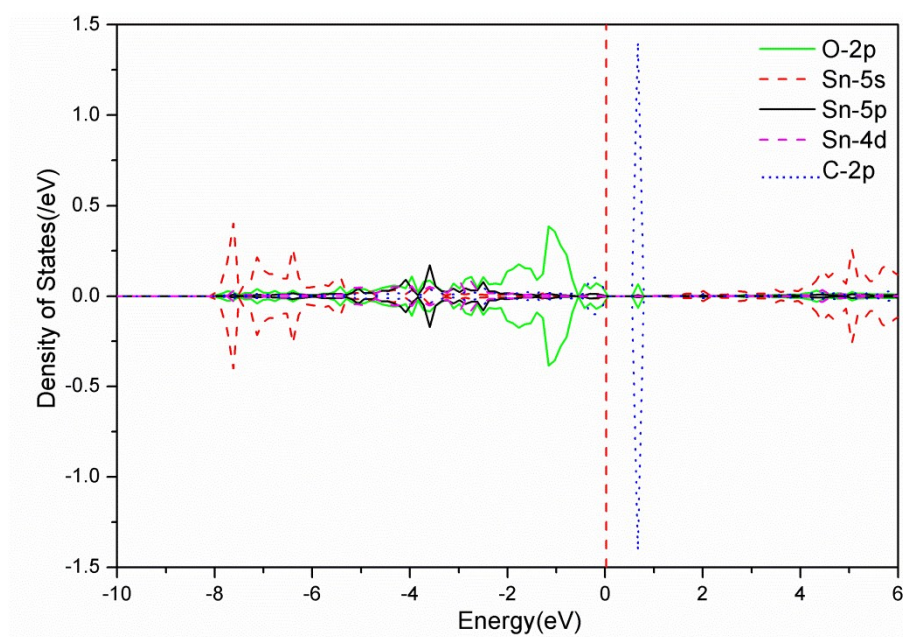
Figure S2. PDOS of bulk SnO$_2$:C materials calculated by GGA function. The vertical red dashed line represents Fermi level.