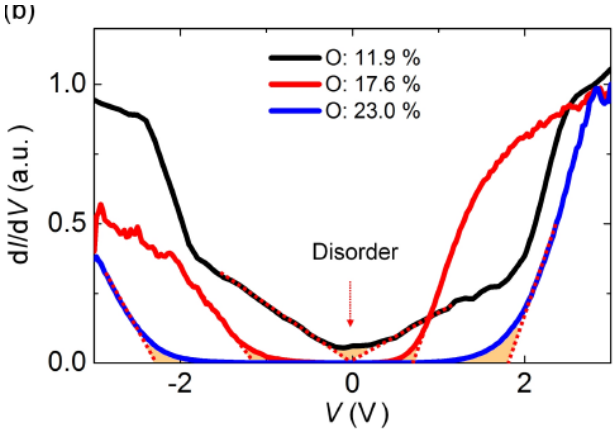
Band gap opening in graphene oxides



Single-layer graphene oxides were reduced to give reduced graphene oxides (rGO) with a broad distribution of oxide coverages in the previous work [1]. Electrical properties of rGO sheets were investigated simultaneously by density of states (DOS) and electron transport measurements. For electron transport measurements, two Ohmic-contacted electrodes were made on rGO and the temperature behavior of resistance and current-voltage (I-V) curves were studied. For the DOS measurement, see Fig., tunneling junction with a thin oxid layer was fabricated on rGO. From the resistivity of rGO sheets, the oxygen coverage of these sheets was estimated to be in the range from 8% to 23%. With an increase of the oxygen coverage on graphene surface, there is an increase of hopping energy and a decrease of localization length as well as the hopping distance from the electron transport measurement. For a high oxygen coverage rGO, the electron transport deviates significantly from the ideal two-dimensional Mott's hopping conduction. The measured DOS demonstrates a gap opening at a oxygen coverage of ~15%. Atomic structure of rGO is proposed here to describe the electron transport variation, band gap opening, and band-tail elongation phenomena. The continuous band gap opening in rGO is modeled by a tight binding model that complements band structure calculations at selected coverages. The main feature of the transition, at which two Dirac points coalecs, is the sixfold rotation symmetry breaking by the oxigen atom binding to a « bridge » of two carbon atoms. The gradual transition from graphene to graphene oxides is experimentally determined and theoretically modeled for the first time.

[1] S.T. Wang, Y.F. Lin, Y.C. Li, P.C. Yeh, S.J. Tang, B. Rosenstein, T.H. Hsu, X.F. Zhou, Z.P. Liu, M.T. Lin, W.B. Jian, *Apl. Phys. Let.* **101**, 183110 (2012).