Electrical Characterization of Multistep NO_2 Adsorption Dynamics in Co-Phthalocyanine-Functionalized Graphene FETs

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We investigated the influence of the amount of cobalt phthalocyanine (CoPc) modification on a graphene field-effect transistor (GFET) toward nitrogen dioxide (NO_2) and performed an electrical analysis of its adsorption behavior. The electrical measurements under NO_2 atmosphere revealed that the Dirac point voltage (DP) shifted in the positive direction upon exposure to NO_2 (Fig. 1). Furthermore, the NO_2 concentration dependence of the DP was well fitted by a two-step Langmuir adsorption isotherm (Fig. 2). Regarding the response magnitude to NO_2, in the low concentration range, the maximum response increased with increasing modification amount, whereas in the high concentration range, a saturation tendency was observed. These results suggest the presence of multiple adsorption sites. Based on comparisons with previous studies[1], the electronic orbitals of phthalocyanine, and adsorption energies calculated from first-principles calculations, it is suggested that in the low concentration range, adsorption predominantly occurs via strong interactions near the central metal, while in the high concentration range, physisorption progresses on the graphene surface surrounded by phthalocyanine molecules and on the six-membered rings of the phthalocyanine.

References

[1] Kazuki Kikawada, *ACS Appl. Electron. Mater*, Issue 9 (2025), 3828-3836

Figures

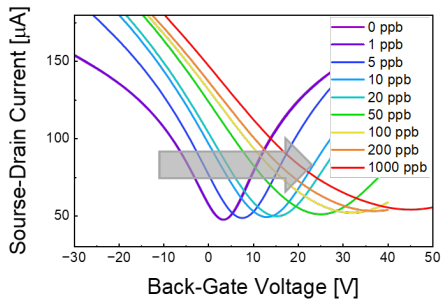

Figure 1: Transfer Characteristics under NO_2 atmosphere (1-1000 ppb).

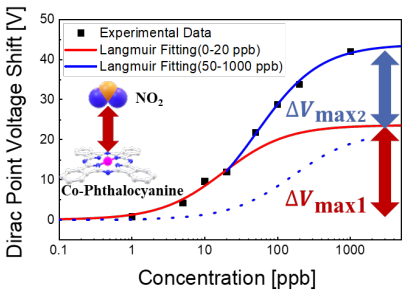

Figure 2: NO_2 concentration dependence of the Dirac Point voltage shifts.