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Gate-Controlled Chemical Modification of Graphene

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Two-dimensional (2D) materials that can be obtained by exfoliation of layered crystals are very sensitive to surface phenomena owing to their ultimate thinness. Their ultrathin body enables us to control the whole body by means of a field-effect-transistor (FET) configuration because the gate electric field penetrates to the top-most surface. Thus, it is expected that surface phenomena are controllable by means of FETs with a channel of 2D materials. In this talk, among various gate-controlled surface phenomena, gate-controlled chemical reactions will be discussed based on chemical modification of an archetypal 2D material, graphene.

The gate voltage (V_G) of FETs can tune the charge carrier density/type in the 2D channel, and control surface adsorption phenomena by the gate electric field. If reactants come from the surrounding environment (e.g., oxygen molecules in oxidation reactions), the adsorption of the reactants onto 2D channels can be a rate-limiting process. In this case, we can control the whole reaction by controlling the adsorption process (Figure 1a) [1,2]. A similar gating effect can be exerted by modifying the supporting substrate surface with a self-assembled monolayer (SAM). A local electric field generated by electric dipoles of constituent molecules of the SAM is found to control a photochemical modification reaction of graphene with benzoyl peroxide (Figure 1b) [3].

References

[1] N. Mitoma and R. Nouchi, Appl. Phys. Lett. **103** (2013) 201605.
[2] R. Nouchi, M. Matsumoto, and N. Mitoma, J. Mater. Chem. C **7** (2019) 1904.
[3] R. Nouchi and K. Ikeda, submitted.

Figures

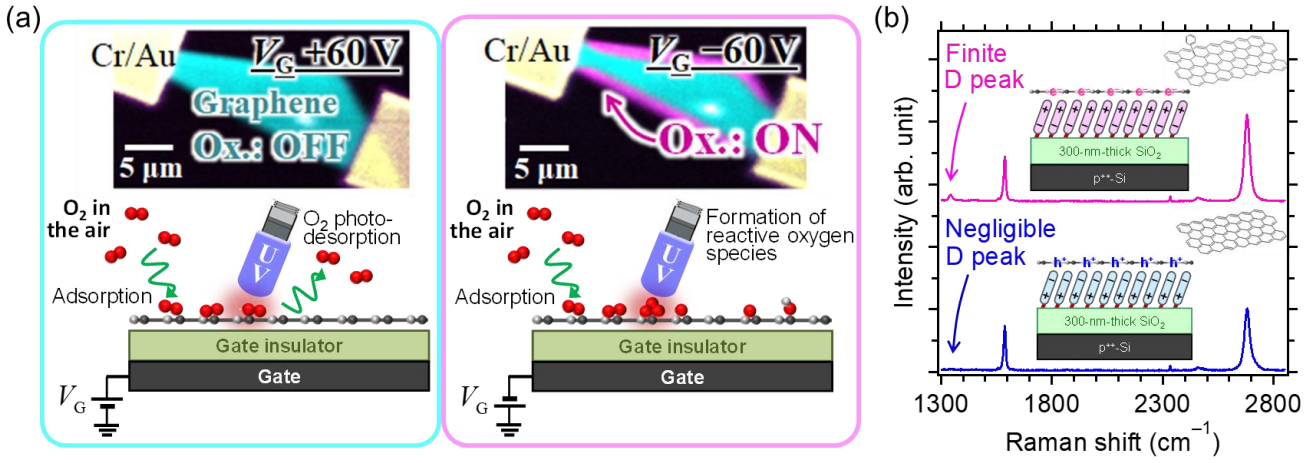

Figure 1: Gate-controlled chemical modification of graphene with (a) an FET configuration and (b) surface modification of a supporting substrate with polar SAMs.