２次元電子デバイスのギャップエンジニアリングと信頼性評価
Gap engineering & reliability study for 2D electronics

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The main issue of downscaling in the Si field-effect transistors (FETs) is the short channel effect in which the gate control is weakened by the drain bias. Based on an analysis of the electrical potential distribution in the channel region, it is well known that the short channel effect can be neglected when the channel length is ~6 times longer than the scaling length $\lambda = \sqrt{(\varepsilon_{ch} t_{ch} t_{ox})/(N\varepsilon_{ox})}$, where N is the effective gate number. This perspective attracts great attention to 2D layered channels in the FET application because of their rigidly controllable atomic thickness (t_{ch}< 1 nm), as well as the low dielectric constant (ε_{ch} = ~4) for typical 2D layered channels. Although old-but-new 2D channels, such as transition metal dichalcogenides, black phosphorus, and so on, have been intensively investigated recently, bilayer graphene still has an advantage over the high performance device from the viewpoint of the smaller effective mass (m_{BLG}=~0.037, m_{BP}=0.13, and m_{MoS2}=~0.37).

In this talk, we focus on two important aspects toward the 2D electronics. First one is the low I_{on}/I_{off} issue for bilayer graphene, which is considered due to the variable range hopping in "gap states". The gap state density (D_{it}) was extracted by the conductance measurements after the precise E_G determination by the quantum capacitance measurement. Two possible origins for the gap states, border traps at the edge of Y_2O_3 and the local breakdown of A-B stacking in bilayer graphene, are discussed. [1] Moreover, our recent results on h-BN encapsulated bilayer graphene will be shown.

The other is reliability issue on an insulating layered material, *h*-BN. It is widely utilized as the substrate and gate insulator to achieve high carrier mobility in layered channel materials. It has not been determined whether the dielectric breakdowns of 2D layered materials follow the general breakdown phenomena for 3D amorphous oxides. In this study, the anisotropic dielectric breakdown of h-BN is studied. [2]

The perspective on the 2D FET application will be discussed in this workshop.

[1] APL, 2014, **104**, 083519. & Sci. Rep. 2015, **5**, 15789.
[2] ACS nano, 2015, 9, 916. & ACS appl. mater. Interfaces, 2016, **8**, 27877.