Two Dimensional Materials for Si technology and other applications

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Two dimensional (2D) materials are crystalline materials with layered structures, including Graphene, h-BN, and Transition Metal Di-chalcogenides (TMD's). We have investigated 2D materials in two directions. For near term research, we explored 2D materials to enhance the performance of Si technology as interface materials due to their atomically thin nature and for long term we looked into new potential applications.

Previously, we proposed inserting Graphene between Si and metal to reduce Schottky barrier height [1], which is one of the most critical interfaces in Si technology. We continued to study the insertion of various 2D materials at the interface to control the Schottky barrier heights. [2, 3] We find that 2D materials may change the pinning point of Schottky barrier and end up reducing contact resistance. We examined Graphene and h-BN in 6" wafer and observed the lowest specific contact resistivities of 3.30 nΩ cm2 with n-type Si 1015/cm3 and 1.47 nΩ cm2 with n-type Si 1021/cm3. We also tested with mechanically exfoliated TMD's and observed that TMD's can reduce the Schottky barrier height.

In addition, we investigated Graphene/metal hybrid interconnect. Although high-quality graphene can be produced on catalyst metals, their Si technology applications are limited by the high temperature growth and the post transfer process. W/nano-crystalline graphene/TiN is realized for downscaling with up to 300 mm wafer with direct growth at a low temperature of 560°C, below the Si technology integration temperature. Graphene in interconnects acts not only as barrier materials and also as the promoter of the preferential grain growth of the W. A reduction of 27% in the resistance of the interconnect is achieved. [4]

As one of the long term applications, we examined triboelectric nanogenerator (TENG), which has been explored as one of the possible candidates for the auxiliary power source of portable and wearable devices. [5] We investigates the triboelectric charging behaviors of various 2D layered materials, including MoS2, MoSe2, WS2, WSe2, graphene, and graphene oxide and confirms the position of 2D materials in the triboelectric series. It is also demonstrated that the results are related to the effective work functions. [6]

References

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