Recent Advances in Graphene-on-SiC RF Electronics

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Graphene has attracted a lot of attention in the research community due to its truly 2D nature and very high intrinsic saturation velocity (V_{sat}) of ~$5x10^7$ cm/sec, providing a potential for high-speed RF applications with different 2D electronic properties unlike the traditional 3D semiconductors. In addition, graphene offers unique properties such as high mobility, excellent scaling properties, symmetry in electron or hole channel, transferrable to any substrates, and their potential CMOS compatibility. Epitaxial graphene materials and graphene field-effect transistors (GFETs) have been under development with high-K/metal gate process. [4-8] The epitaxial material quality is being improved to a level that is comparable to SOA lattice-matched InP with sheet resistance of ~ 200 ohm/sq and its variation down to ~3 % on 100 mm wafers. The ohmic contact process is being developed with contact resistance ~0.03 Ω·mm, resulting in a lowest on-state resistance of 0.13 Ω·mm and a highest saturated source-drain current of ~ 3 A/mm at Vds = 1 V. A challenging issue with high-K gate dielectric on GFETs is being resolved to a level that trap-induced hysteresis is not a concern for RF applications. The reduction of parasitics in GFETs is enabling a proper scaling of gate length (Lg) and extrinsic ft/fmax accordingly to reach a goal of ft*Lg = 32. Various RF circuit concepts such as high dynamic range linear mixers up to 40 GHz and high dynamic range millimeter wave radiometers up to 220 GHz are being evaluated with noise characterization. In parallel, bandgap engineering of graphene is being developed to graphene heterostructure devices with Ion/Ioff ratio of > 10^5.

In this talk, we present recent progress in graphene material, GFETs, heterostructures, graphene NEMS, graphene-on-flexible medium, and potentially disruptive RF applications of GFETs. Continuous development of emerging graphene would potentially improve existing RF systems with integration with standard Si/III-V RFICs similar to DARPA heterogeneous integration (DAHI) efforts, and enable a new generation of high performance 3D-RFICs.

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