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Graphene for Nanoelectronic Devices And Interconnects

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Carrier mobility is one of the important parameters which decide the performance of a MOSFET. At nanometer scales, the carrier mobility falls due to severe high electrical fields in silicon (Si) MOS transistors. Graphene Field Effect Transistors (GFETs) are evolving at a rapid pace and are considered as an option for post-Si electronics. Graphene is a high mobility semiconductor material which has a capability and all properties to replace Si altogether for nanoscale technologies. Graphene is a single atomic layer of carbon atoms arranged into a two-dimensional (2D) hexagonal lattice. The initial work on graphene for microelectronic devices started in 2004. There are basically three types of GFET fabrication. These are exfoliation, epitaxial and Chemical Vapor Deposited (CVD) techniques. Mainly two types of graphene sheets are produced. One is with a bandgap and the other without the bandgap. The graphene sheet which has a bandgap is called semiconducting Graphene Nanoribbons (GNR). For digital applications, FETs with the ability to switch are needed. GFETs without a bandgap large-area channels cannot be switched off and are unsuitable for a logic functions. To obtain good switch-off, a FET needs a semiconducting channel. Thus, GNR channels are needed. However, to create a large bandgap for good switch-off, extremely narrow GNRs are needed. This represents a challenge for fabrication and a reliable method is required to produce such narrow GNRs. The other problem with GNRs is that the carrier mobility is dramatically reduced.

Another challenge in implementing GFETs is the development of compact models for these FETs. The challenge lies in the efficient modeling of edge scattering and edge bond relaxation in graphene sheets. Further the models must also include the capacitive analysis and the charge transport analysis in the FET. Some attempts have also been made to model GFETs using the numerical models.

The other area of application of graphene is use in interconnections. With shrinking dimensions of copper (Cu) interconnects, their resistivity and reliability have become important issues for nanoscale circuits. Actually, the main requirement in nanoscale interconnects is the reduction in delay. The delay is a function of interconnect resistance and capacitance. Carbon-based nanomaterials are a good candidate for new interconnect materials, because of their lower resistivity and intrinsically higher reliability, i.e. Electro-Migration (EM) tolerance, compared with a conventional Cu interconnects. GNRs with smooth edges can have smaller resistances compared with Cu wires. There have been several models developed to describe the resistance in GNR interconnects. The crosstalk in GNR interconnects is also an important issue which should be minimum. So, to implement graphene as a mainstream material, the challenges posed by this material need to be tackled.

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