Opportunities and challenges of graphene application in passive micro- and millimetre wave components

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Abstract - Graphene was first isolated in 2004 and since numerous application concepts based on graphene have been demonstrated [1]. Graphene been recognized from the very beginning as promising candidates for future radio electronics because graphene shows extraordinarily large carrier mobility [2].

Up to now most of the radio related research focuses very much on development of high frequency graphene transistors. In just a few years, high frequency graphene transistors have reached a performance level rivalling the best semiconductor devices that have over sixty years research effort behind them [2,3].

However other unique properties of graphene have not been utilized so much in high frequency analog electronics so far. For example single-layer graphene has very low density of states, which leads to a strong quantum capacitance effect. Quantum capacitance of the graphene depends on applied voltage [4]. This effect has been used in varactors.

No radio circuitry can be built without passive components. It would be important to understand how visible to use graphene for fabrication passive radio components.

In this paper we evaluate opportunities of usage of graphene in passive micro- and millimetre wave components.
The paper is presenting

- ✓ the physical properties of graphene in terms of its application in passive micro and millimeter wave components;
- ✓ review of applications of graphene in passive components including antennas, transmission lines, inductors and varactors
- ✓ new type of a phase shifter based on effect of dependence of quantum capacitance on applied voltage are proposed and theoretically analyzed.

Analysis shows that high resistance of single layer graphene is the main challenge of usage of graphene in passive devices. Though graphene is the best electrical conductor known, it is mono-atomic and thus the surface resistance is very high compared to metals at micro and mm-waves frequencies, even with the possibility of doping and electric field biasing of graphene. In these frequency ranges graphene is thus mostly a moderate to bad conductive surface. At microwave and mm-wave frequencies, graphene conductivity is essentially real and the electric field bias allows controlling this resistivity over a certain range.

The picture is quite different at terahertz frequency range above 500 GHz, as a result of the plasmonic nature of the imaginary conductivity allowing plasmonic modes. At terahertz electric field affects strongly the imaginary part of the graphene conductivity. This mode can be used in tunable terahertz devices, for example terahertz antennas and filters

References

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