## Microwave-to-terahertz investigation of CVD graphene: towards sensor- and communication applications

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From a microwave engineer's perspective, graphene is a resistive sheet with a real-valued surface impedance and almost no dispersion up to one terahertz and beyond. Due to its unique electronic structure, the sheet resistance of graphene can be controlled by an external gate voltage, by light irradiation or by chemical doping due to a molecular monolayer attached to the graphene surface, which enables external control of the reflectivity of a graphene layer over a wide range.

The microwave-to-terahertz properties of CVD (chemical vapor deposition) graphene layers transferred on low-loss microwave substrates have been investigated by various microwave- and millimetre wave resonator methods and compared with THz time domain spectroscopy. Due to the real-valued surface impedance, the device quality factor is controlled to a large extend by the sheet resistance of graphene, if a transferred CVD layer is integrated as part of a resonant device. Specifically, it was shown that a ceramic dielectric resonator at X-band frequencies (Fig. 1) can be utilized for contact-free determination and mapping of the sheet resistance of large-area graphene layers deposited on low-loss substrates, and for real-time monitoring of externally induced alterations within an open device configuration (Fig. 1, right).

As a first step towards a fully integrated device, a graphene layer was incorporated in a photonic crystal-based high-Q resonant device (Fig.2), which was prepared by reactive ion etching from high resistive silicon. The device properties at 100 GHz were studied by simulation and S-parameter measurements were performed by a millimeter-wave vector network analyzer.

Based on these results, concepts for integrated sensor and communication devices at millimetre wave frequencies will be discussed. Due to the shortcomings of semiconductor technology for this frequency range, state-of-art CVD graphene has a realistic application potential, which range from Gbit/s WIFI towards biosensors.

[1] W. J. Otter et al. submitted to IEEE MTT

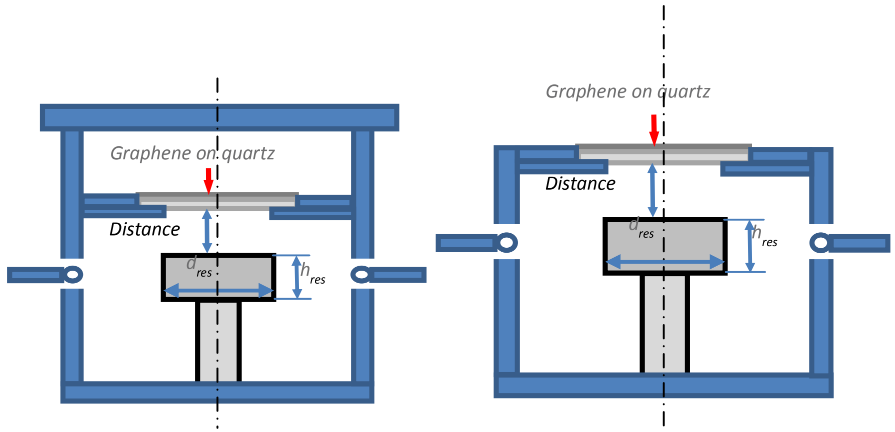


Fig.1 : Dielectric resonator for graphene sheet resistance characterization at X-band frequencies

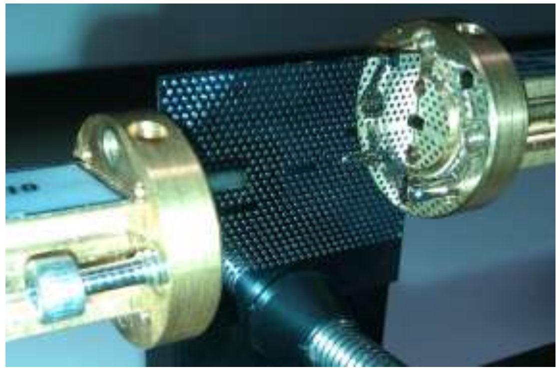

Fig.2: 100 GHz high Q photonic crystal resonator made from high resistive silicon (from [1])