

# A Graphene-based quantum capacitance varactor for millimeter-Wave applications

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This work presents a novel Graphene-based variable capacitor (GVAR), which was fabricated with an in-house developed full-fledged Graphene MMIC technology- [1]. The GVAR consists of a Metal-Insulator-Graphene stack as shown in Fig.1. The low density of states of Graphene together with the proper physical design ensure that the voltage-dependent, nonlinear quantum capacitance ( $C_Q$ ) dominates over the voltage-independent, linear geometric capacitance ( $C_G$ ), which is defined by a 6 nm thick TiO<sub>2</sub> dielectric-layer. In addition, Graphene has very high carrier mobility and zero bandgap, which make it a very good candidate for low loss devices. The proposed layout design in addition reduces the losses represented in the series resistance leading to further improvements of the quality factor and the cutoff frequency of the GVAR.

The GVAR is fully characterized, and modelled up to 100 GHz demonstrating a clear voltage dependency of the capacitance both at low and high frequencies (Fig. 2). Based on the excellent measured high frequency characteristics of the fabricated devices they are suitable to be used in various millimeter-wave circuit applications.

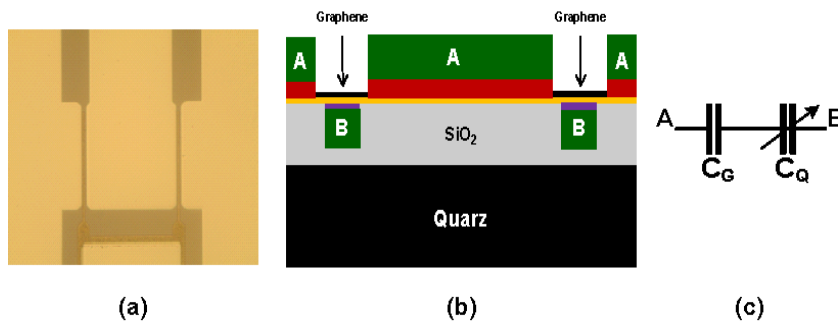


Fig. 1. GVAR concept of operation (a) GVAR layout (b) physical structure of the GVAR (c) Equivalent series capacitances.

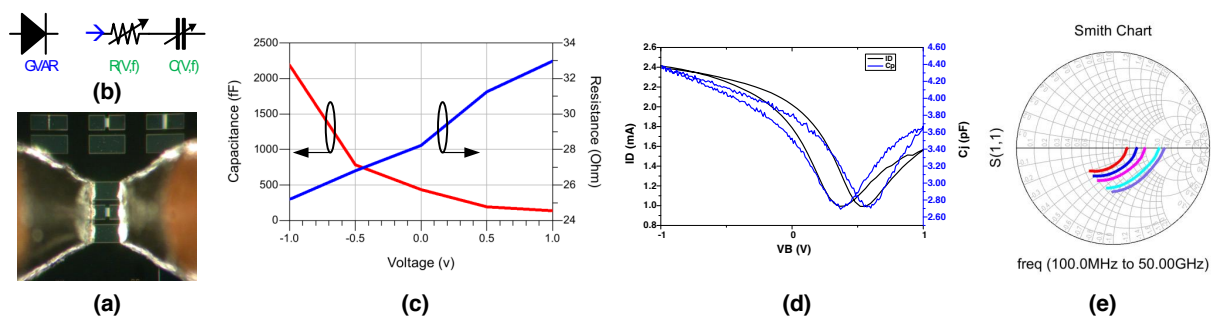


Fig. 2. GVAR characterization, (a) Die micrograph, (b) Equivalent model of GVAR for parameter extraction, (c) Characterization results at 50 GHz, (d) RLC measurements at 10 MHz, (e) RF characterization from 100 MHz to 50 GHz.

## References

[1] A. Askar, et al., "Graphene-based MMIC Process Development and RF Passives Design," German Microwave Conference 2015, Nürnberg, Germany, March 2015