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Temperature-Dependent Microwave Characterisation of Ion-Implanted Materials for Graphene-on-SiC enabled systems

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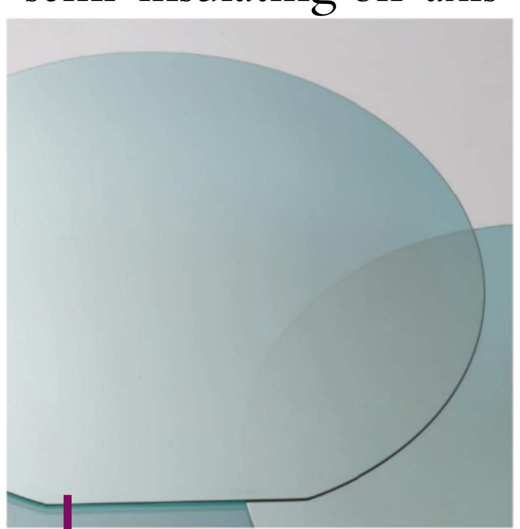
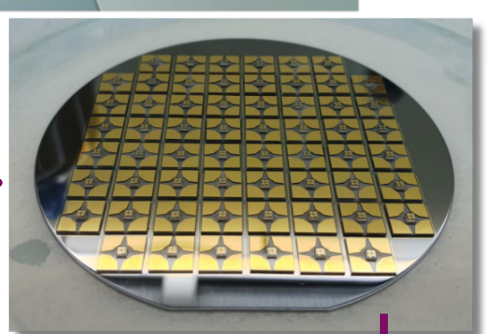
Silicon carbide (SiC) is a wide-bandgap semiconductor, advantageously used in hightemperature and/or high-voltage electronics. Recent interests are observed in Graphene-on-SiC (GRSiC) enabled systems, with a proven potential for magnetic field detection (including medical diagnostics), power monitoring and chemical sensing. From that perspective, a challenge resides in the observed decrease of SiC resistivity at higher temperatures, which the ongoing European project aims to mitigate with low-energy ion implantation (LEII) of SiC substrates prior to graphene epitaxy. While initial characterisation performed at DC seemed to confirm that such LEII treatment restricts the evolution of the electron channel and improves thermal stability of the considered GRSiC devices, our microwave measurements indicate that different phenomena need to be taken into account at higher frequencies. We shall present the results of comprehensive characterisation: performed with QWED SPDR and Q-SCR instruments in the 5-35 GHz frequency range over the 20 - 90 deg C temperature range; for three samples of semi-insulating high-purity nominally on-axis 4H-SiC(0001), reference (unimplanted) and pre-epitaxially implanted with 10 keV or 40 keV hydrogen (H+) ions, respectively. On each sample, grahene was epitaxially grown and then removed, to further investigate the effects of such processes on the SiC substrate.

Ion implantation for graphene-enabled magnetic diagnostics: Application perspectives in modern fusion reactors

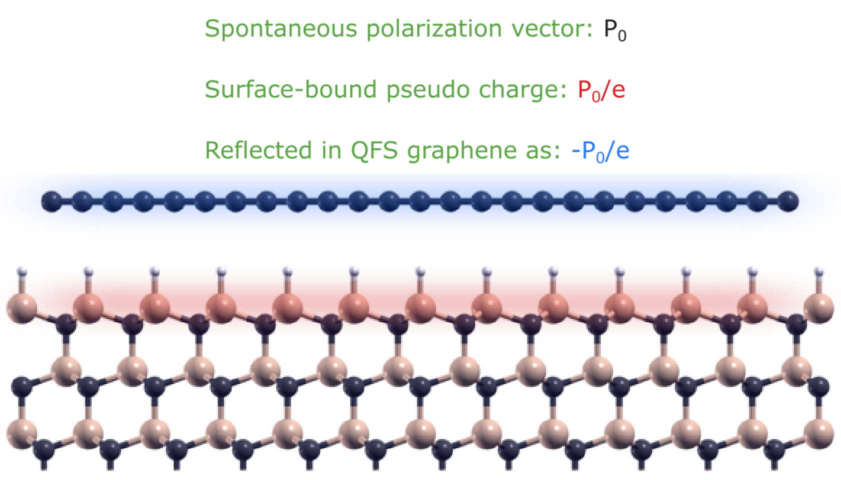
4H-SiC (0001)
semi-insulating on-axis



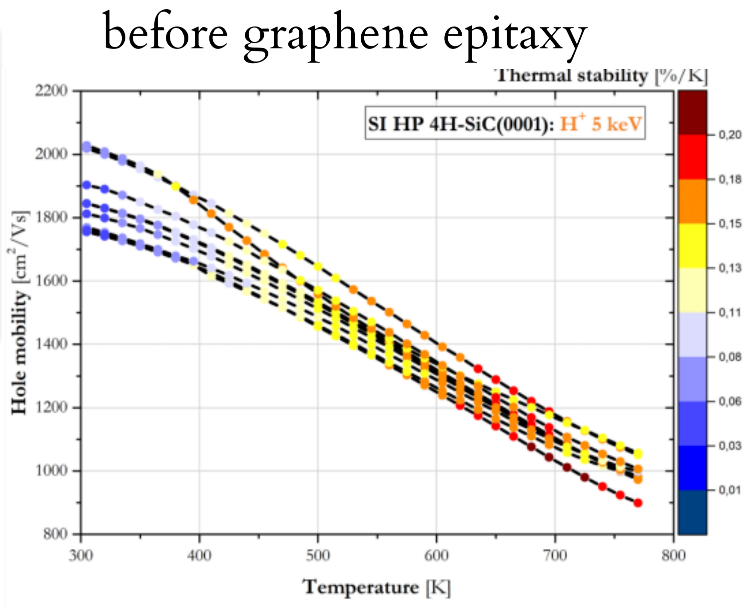


Van der Pauw method: The input is a direct current, and the output consists of an offset voltage along with the Hall voltage.

Quasi-free-standing graphene

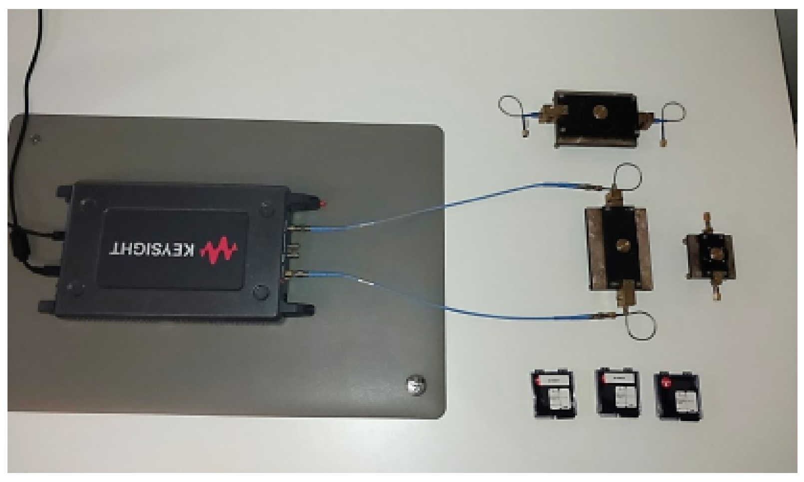


4H-SiC is treated via ion implantation before graphene epitaxy



Measurement Setup

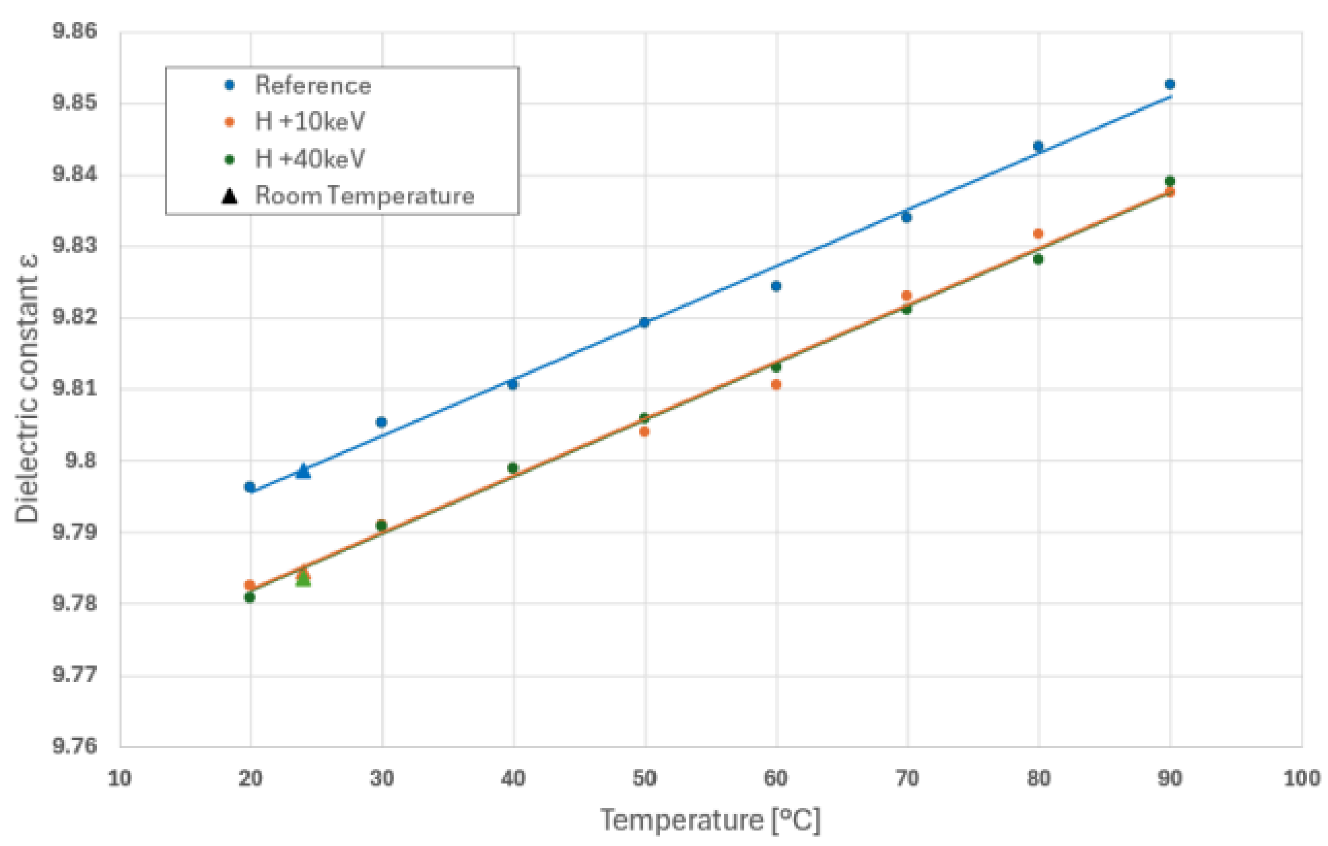
10 GHz Split Post Dielectric Resonator in Climate Chamber with inserted 4H-SiC treated by Ion implantation



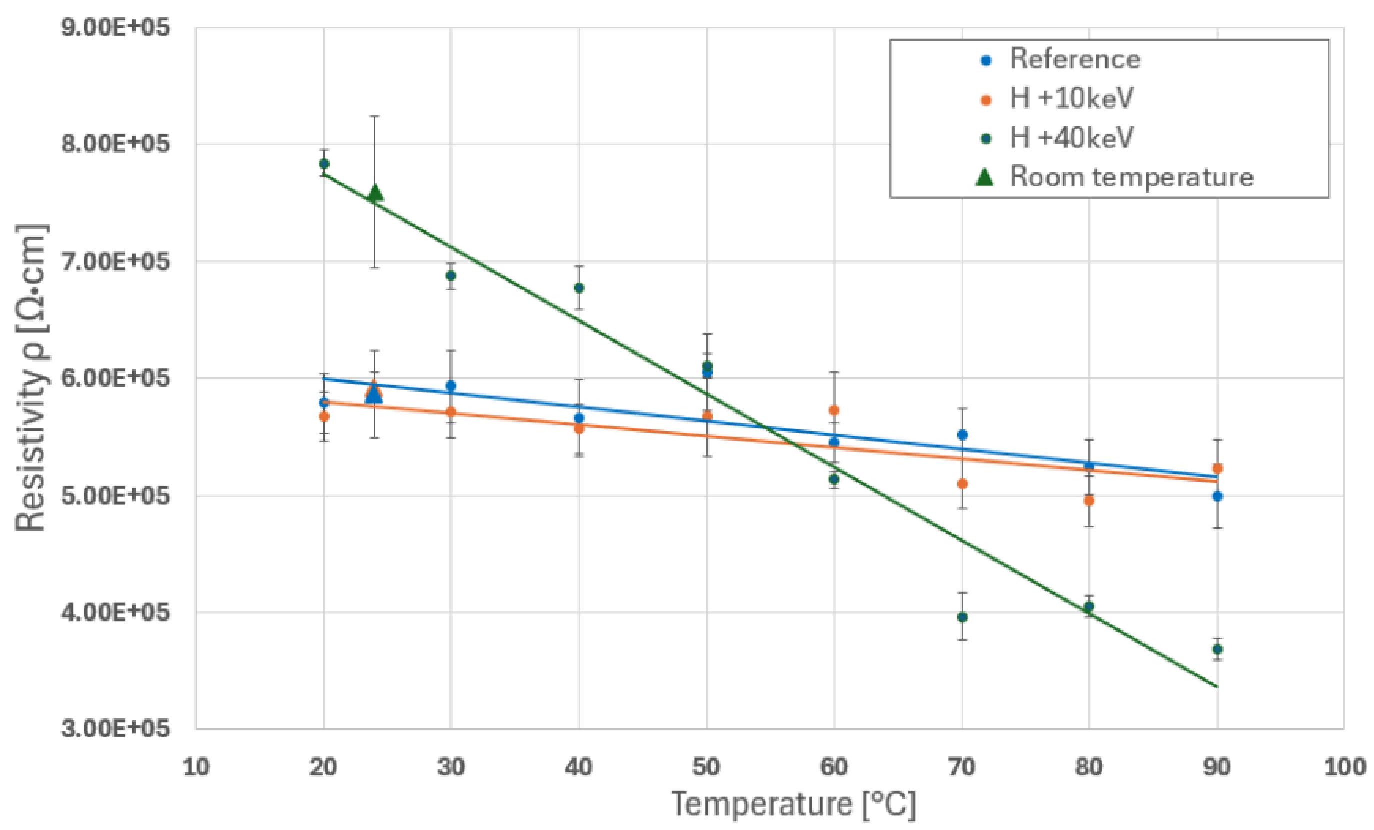
stand-alone SPDRs available for 1.1-15 GHz

The application of SPDR consists in precise measurement (using an external electronic device like VNA) of the resonant frequency and loaded Q-factor of the resonator alone and the same resonator loaded by the measured sample. The actual material properties are extracted from those measurements using customised software supplied with the resonator. The software is based on electromagnetic simulations but includes also postmanufacturing corrections concerning a particular copy of the SPDR.

Results



Dielectric constant of 4H-SiC treated by Ion implantation from 20 °C to 90 °C



Resistivity of 4H-SiC treated by Ion implantation from 20 °C to 90 °C

Acknowledgement

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I4Bags project website: