Graphene field-effect transistors on $LiNbO_3$ ferroelectric substrates

A. Vorobiev,[1,*] S. Bidmeshkipour,[2] M. A. Andersson[1], A. Kompany[2] and J. Stake[1]

[1]Department of Microtechnology and Nanoscience, Chalmers University of Technology, SE-41296 Gothenburg, Sweden

[2]Department of Physics, Ferdowsi University of Mashhad, 9177948974, Mashhad, Iran

[*]Corresponding Author: andrei.vorobiev@chalmers.se

The property of very high carrier mobility and velocity in graphene enables the possibility of much faster electronics than with traditional semiconductors. However, the channel mobility in graphene field-effect transistors (G-FETs) is usually strongly degraded by Coulomb scattering caused by charged impurities. Additional issue is the zero-bandgap in monolayer graphene, which limits the high frequency power gain of the G-FETs. The both issues can be effectively addressed by using ferroelectric as a G-FET substrate. The field of the ferroelectric polarization screens the charged impurity field [1] and, also, can be used for bandgap engineering in the bilayer G-FETs [2]. In this paper, we report the effect of $LiNbO_3$ ferroelectric substrate on the carrier mobility in top gated monolayer graphene field-effect transistors (G-FETs). We show that, at the same residual concentration of the charge carriers, the mobility in G-FETs on $LiNbO_3$ substrate is higher than that on the SiO_2/Si substrate (Fig. 1). The effect is associated with reduction of Coulomb scattering via screening the charged impurity field by the field induced in the ferroelectric substrate [2], but significant only for mobilities below 1000 cm^2/Vs. Raman spectra analysis [3] and correlations established between mobility and microwave loss tangent [4] of the Al_2O_3 gate dielectric indicate that the charged impurities are located predominantly in the gate dielectric and/or at the gate dielectric/graphene interface and likely associated with oxygen vacancies. The gate dielectric technology optimization may allow for significant increase in the carrier mobility up to the limitations by other scattering mechanisms. The measured characteristic frequencies of the G-FETs on $LiNbO_3$ substrates are approx. 2 GHz (Fig. 2) and limited mainly by parasitic capacitance at the source/drain electrode side walls. The corresponding intrinsic cutoff frequency for mobility of 300 cm^2/Vs is up to 10 GHz.

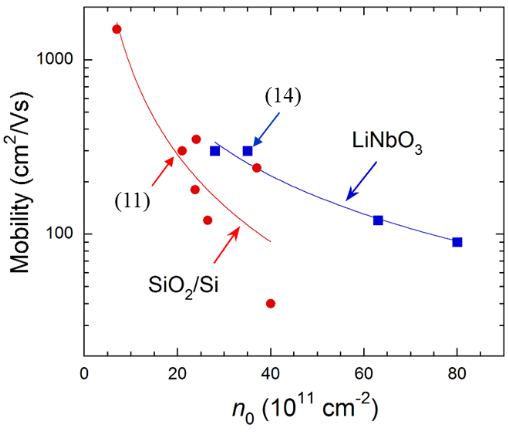

Figure 1. Hole mobility of the G-FETs on SiO_2/Si (circles) and $LiNbO_3$ (squares) substrates versus residual concentration of charge carriers (n_0). Lines are fitting curves.

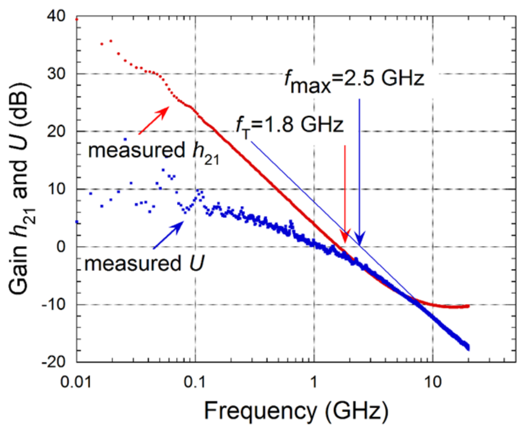

Figure 2. Small-signal current gain h_{21} and unilateral power gain U of the G-FET with gate length of 0.6 μm on $LiNbO_3$ substrate corresponding to the label (14) on Fig. 1.

References

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