Ultra-wide Bandgap Semiconductors Devices and Properties

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Ultra-wide bandgap semiconductors (diamond, β-Ga_2O_3) are touted for their outstanding intrinsic properties which promise tremendous devices performances advantages for power control and conversion applications. Over the last few decades, progress in materials growth and doping allowed the extension of most of known power devices technologies to ultra-wide bandgap semiconductors. Nowadays, the achievement of high-performance devices that leverage the exceptional properties of ultra-wide bandgap semiconductors is the primary concerns. To this end, much remains to be understood in many areas such as devices physics, the effects of defects (intrinsic and extrinsic) on transport properties, and devices design (edges termination issues).

This presentation will focus on the photoionization of deep traps in gallium oxide and diamond, and the electrical properties of advanced devices such as FETs. The electrical properties and thermal stability of p-channel diamond MOSFETs will be discussed [1]. Diamond MOSFETs exhibit typical normally-off MOSFET features from 6.5 K to 623 K. Despite the high impurity ionization energy in diamond (donor: 0.58 eV, acceptor: 0.38 eV), an inversion channel is formed in diamond MOSFETs at low temperature (up to 6.5 K). Moreover, the high-temperature measurements induce an irreversible shift in the threshold voltage of diamond MOSFETs (from −6.5 V to −3.15 V), leading to a significant improvement of the room temperature drain current (see Fig. 1). The threshold voltage shift results from a reduction of the total density of the extrinsic charges at Al_2O_3/diamond interface because of unintentional post-deposition annealing of the Al_2O_3 gate oxide at high temperature. On the other hand, we will report persistent photoconductivity in floating zone β-Ga_2O_3 substrates [2] and $(Al_xGa_{1-x})O_3/Ga_2O_3$ heterojunctions (see Fig. 2). The photo-generated current in β-Ga_2O_3 has been measured using a supercontinuum laser with photon energy ranging from 1.24 to 3.1 eV. The photoionization spectra and the photoionization thresholds of detected deep traps will be discussed.

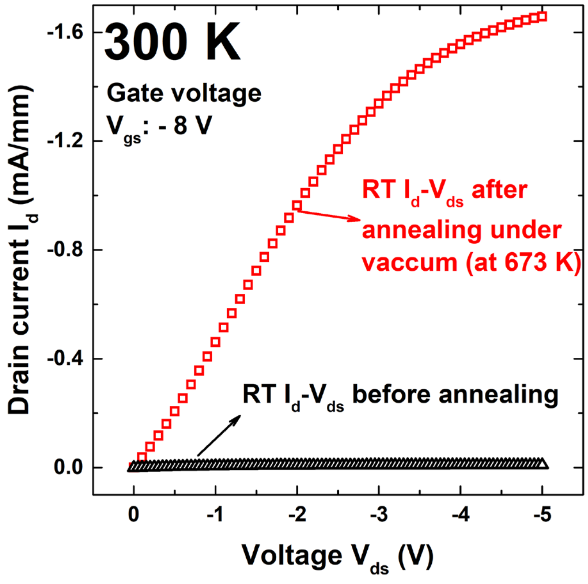

Fig. 1: Effect of annealing on RT I_d-V_{ds} characteristics of a p-channel diamond MOSFET

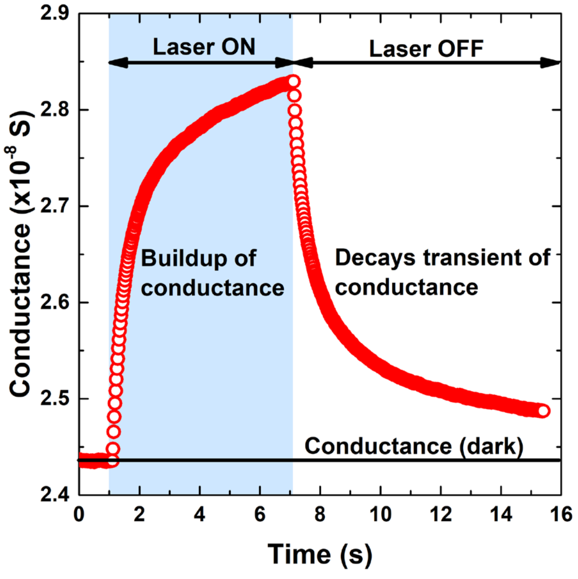

Fig. 2: Buildup and decays transient of photoconductance of β-Ga_2O_3 (600 nm light illumination)

[1] A. Traore *et al.*, Jpn. J. Appl. Phys. 59, SGGD19 (2020)
[2] T. Ito *et al.*, Jpn. J. Appl. Phys. 58, 110908 (2019)