Surface Transfer - Modulation Doping at a Diamond-Dielectric Interface

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Great strides in diamond wafer technology and diamond epitaxy have inspired new concepts for diamond electronics particularly for power conversion and RF applications. However, the high activation energy of substitutional p- and n-type dopants in diamond has limited the development of field effect transistors (FET). An alternative approach of charge transfer doping at a diamond-dielectric interface, which results in the formation of a hole accumulation layer, is not limited by thermal activation [1]. However, the hole transport shows a mobility that is much lower than predicted. It is widely accepted that the low mobility is due to scattering from the near interface negative charges transferred into the dielectric layer.

Following the concept of modulation doping at heterostructure interfaces [2], we have proposed and demonstrated (Fig. 1) a dielectric layer configuration that results in a nearly ten-fold mobility increase for the accumulated holes at the diamond interface [3]. In this approach MoO_3 is used as the charge transfer dielectric, and Al_2O_3 is employed as the modulation doping spacer layer. The charge transfer is driven by the energy difference between the diamond valence band and the charge transfer states in the MoO_3. The thickness of the spacer layer also affects the hole accumulation layer charge density.

In this study photoemission spectroscopy is employed to measure the band alignment and band bending throughout the multi -layer structure. The relative distribution of the charge near the interface is deduced from the band diagram. Another study developed a modulation doping approach using acceptor molecules (NO_2) to enable the charge transfer from the diamond valence band. They achieved results that were similar to the multi dielectric layer approach.

These experiments and the model of Surface Transfer - Modulation Doping demonstrates a new approach to FET channel doping for diamond field effect transistors. We also discuss options for improving modulation doping in diamond FET's.

This research was supported by a grant from MIT-Lincoln Laboratories and the NSF through Grant Nos. DMR-1710551 and DMR-2003567.

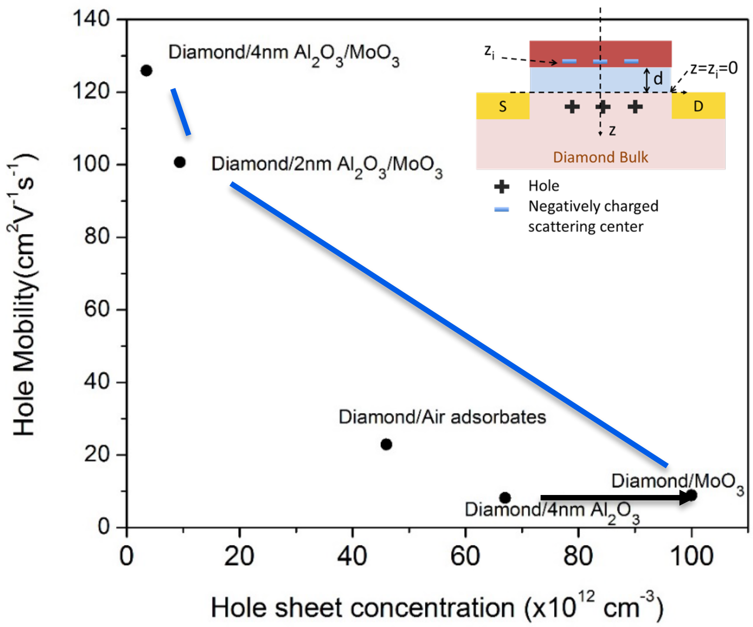

Fig. 1. Mobility vs hole sheet concentration for various charge transfer structures on diamond. The blue lines connect the surface transfer – modulation doping structures with different modulation spacer thicknesses.

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