Ultrafast electro-absorption graphene modulators with a 2D-3D integration of hBN and a high-κ dielectric.

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Abstract

Electro-absorption (EA) waveguide-coupled modulators are essential building blocks for on-chip optical communications. Compared to state-of-the-art silicon (Si) devices, graphene-based EA modulators promise smaller footprints, larger temperature stability, cost-effective integration and high speeds [1]. However, combining high speed and large modulation efficiencies in a single graphene-based device has remained elusive so far. In this work, we overcome this fundamental trade-off by demonstrating the first 2D-3D dielectric integration in a high-quality encapsulated graphene device. We integrated hafnium oxide (HfO_2) and two-dimensional (2D) hexagonal boron nitride (hBN) within the insulating section of a double-layer (DL) graphene EA modulator (Fig. 1a). This novel combination of materials allows for a high-quality modulator device with record high performance: a bandwidth (BW) beyond 40GHz (Fig. 1c) with a three-fold increase in modulation efficiency (Fig. 1b) compared to previously reported high-speed modulators. This first demonstration of 2D-3D integration paves the way to a plethora of electronic and opto-electronic devices with enhanced performance and stability, while expanding the freedom for device designs.

REFERENCES

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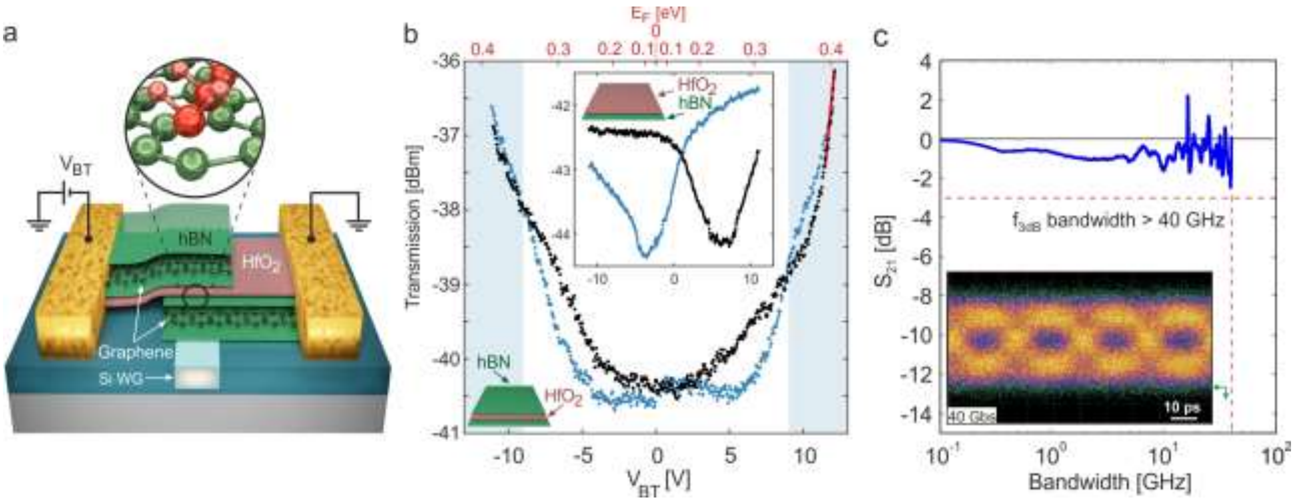

Figure 1: a) Sketch and connections of the EA modulator with a hBN-HfO2-hBN dielectric. b) Transmission as a function of the applied voltage V_{BT}. The forward and backward voltage sweeps are indicated in black and blue. The red line is a linear fit to the data within a 0.5V voltage span (slope: 2.2 dB/V). The inset shows the transmission of a modulator with a hBN-HfO2 dielectric. c) Frequency response of the modulator and eye diagram measured at 40Gbps. The green arrow indicates the 0W power baseline.