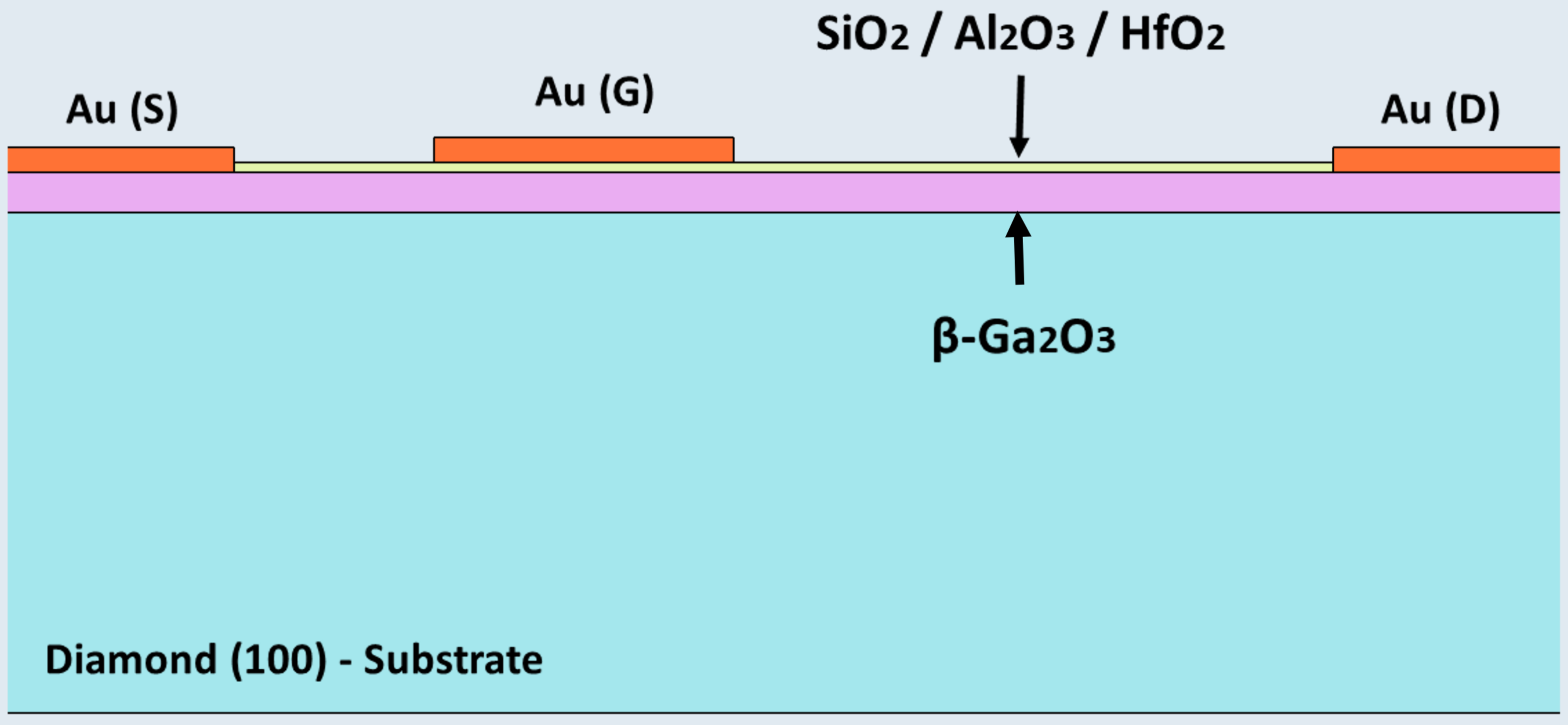

Dielectric Influence on a 2D Lateral Gallium Oxide (Ga_2O_3) MOSFET using COMSOL Multiphysics

Study the electrical and thermal response of a 2D lateral Gallium Oxide MOSFET using different gate dielectric oxide materials to investigate the effect of dielectrics on dissipating heat in the Ga_2O_3 layer.

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Abstract

Gallium Oxide (Ga_2O_3) is an emerging wide bandgap transparent oxide semiconductor that has garnered attention for power electronic applications because of its large 4.8 eV bandgap and large critical electrical field strength of 8 MV/cm [1]. However, due to Ga_2O_3's poor thermal conductivity k = 27 W/mK the self-heating effects can severely limit device performance and reliability. This work studies the electrical and thermal response of a 2D lateral Ga_2O_3 MOSFET using different gate dielectric oxide materials to investigate the effect of dielectrics on dissipating heat in the Ga_2O_3 layer. The three gate dielectrics considered are Silicon Oxide (SiO_2), Aluminum Oxide (Al_2O_3), and Hafnium Oxide (HfO_2). The results show that Al_2O_3 dissipates approximately **27%** to **29%** more heat compared to SiO_2 and HfO_2, respectively.

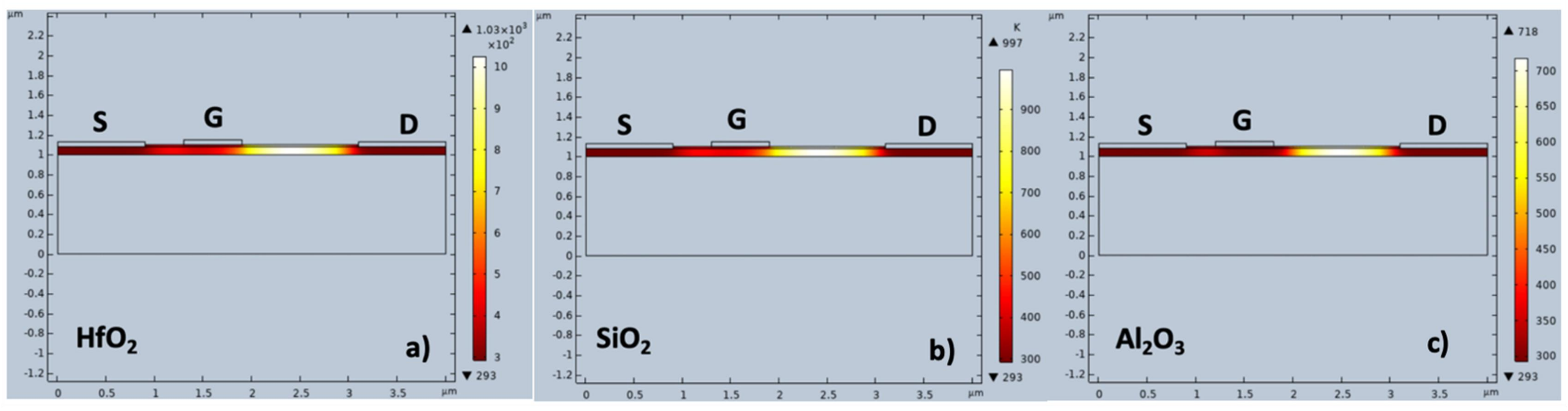

FIGURE 1: Phonon generation plots of the 2D Lateral Ga_2O_3 MOSFET for three dielectrics considered: **a)** HfO_2, **b)** SiO_2, and **c)** Al_2O_3

Methodology

A 2D Lateral MOSFET model was constructed using an **80 nm** thick Ga_2O_3 layer for the semiconductor layer. In addition, a **20 nm** oxide layer is used that alternates between SiO_2, HfO_2, and Al_2O_3. Finally, the source, drain and gate of the device are **50 nm** ideal ohmic Au layers.

Charged carriers and phonon generation are modeled in COMSOL Multiphysics using the **Semiconductor** and **Heat Transfer in Solids modules**. Terminals are defined at the metal contacts to apply a bias to the device while the heat source is defined as the semiconductor layer. Convective heat flux boundaries are applied to the metal contacts to imitate heat generation from device operation.

Results

The gate of this device was held at a constant 5 V bias while the drain was swept from -1 V to 12 V with a 0.1 V step. The source was grounded to operate this device in enhancement mode. The results show that Al_2O_3 helps dissipate heat more effectively compared to SiO_2 and HfO_2 as a gate dielectric.

A peak temperature of **718.2 K** was observed for Al_2O_3 as a gate dielectric, while SiO_2 had a peak temperature of **996.6 K** and **1025.4 K** for HfO_2. Al_2O_3 shows a **27.94%** and **29.96%** reduction in temperature compared to SiO_2 and HfO_2 respectively under the same operating conditions.

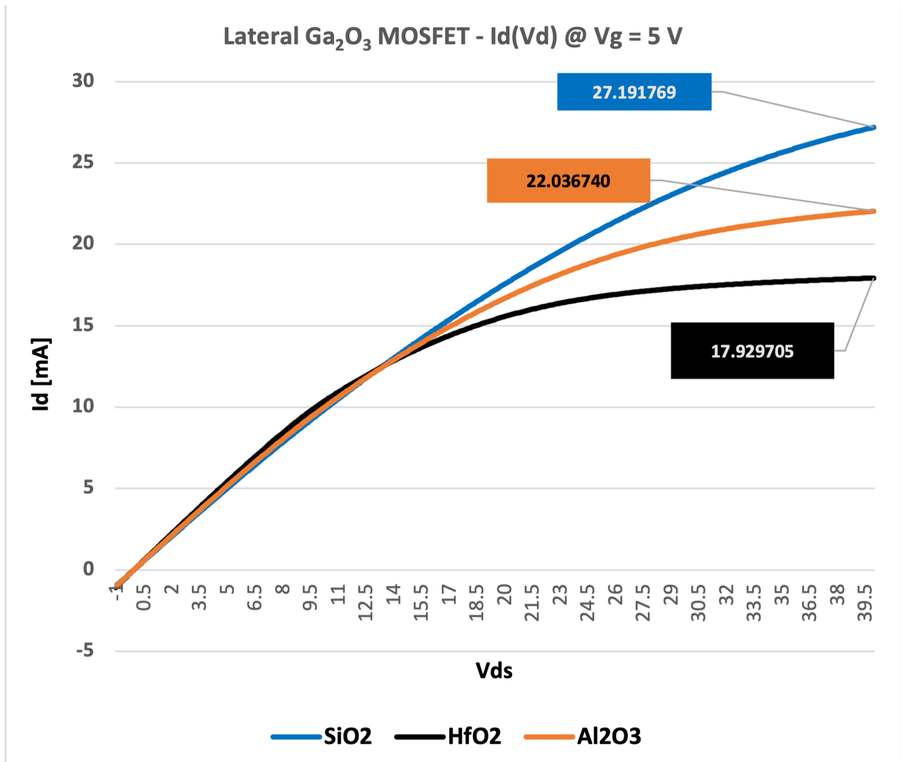

FIGURE 2: Comparison of output drain current **Id(Vd)** of 2D Lateral Ga_2O_3 MOSFET for the three dielectrics HfO_2, SiO_2, and Al_2O_3 evaluated

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