Finite Element Modeling Of An AlGaN/GaN Based VOC Sensor Using COMSOL®

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Abstract

Volatile organic compounds (VOCs) are a large group of chemicals that can be found in many products that we use to build and maintain our homes. Some of the VOCs such as benzene, formaldehyde, ethylene glycol, etc. can be found in our everyday life in the form of paints, cleaning agents, and room fresheners. Once these chemicals are in our homes, they are released into the indoor air we breathe. Long term exposure to VOCs by human beings will cause adverse health effects. Therefore, the detection of VOCs is an essential step in indoor air quality monitoring. To detect VOCs, so far there are three types of techniques that are widely studied in the literature. They are photoionization detection (PID), flame ionization detection (FID), metal oxide sensors (MOS). In this paper, a novel AlGaN/GaN cantilever has been proposed to detect the VOCs. The proposed cantilever has been modeled in COMSOL® to compute the temperature profiles with and without the presence of VOCs respectively by utilizing AC/DC, Heat Transfer (HT), and Computational Fluid Dynamics (CFD) Modules in COMSOL®. The 3D geometry of the AlGaN/GaN cantilever is shown in Fig. 1. The thickness of the metal stacks, AlGaN, and bottom GaN layers is 230 nm, 220 nm, 20 nm, and 1.3 µm, respectively. Using the Electric Currents interface in COMSOL®, a DC bias voltage is applied to the metal stack to compute the current density and resistive heat loss profiles on the cantilever. The resistive heat loss data obtained from the AC/DC Module is given as input to the HT Module to solve the heat equation. Convective and radiative heat losses are also considered in the simulation. The Electric Currents and Heat Transfer interfaces are coupled to obtain the temperature profiles of the cantilever at different bias voltages. The current density and temperature profiles of the cantilever at a bias voltage of 10 V is shown in Fig. 2 and 3 respectively. In the presence of different VOCs, the temperature profile of the cantilever varies. When VOC flows on the heated cantilever, the latent heat from the cantilever is absorbed by the VOC. Due to this heat transfer, the tip region of the cantilever gets cooled. By coupling the HT and CFD Modules, the changes in the temperature profile of the cantilever due to the presence of a VOC has been simulated.

Figures used in the abstract

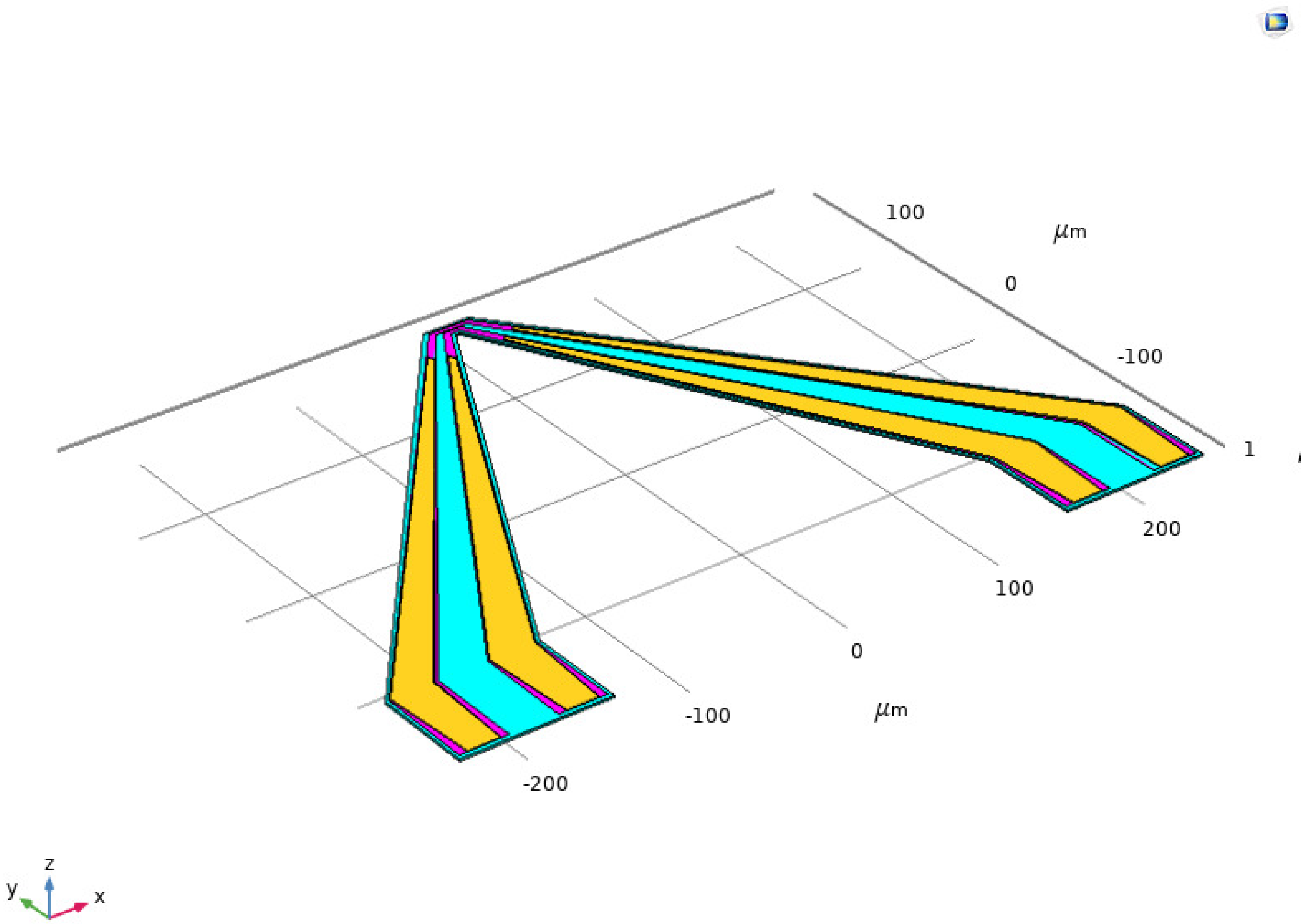

Figure 1 : 3D geometry of AlGaN/GaN cantilever

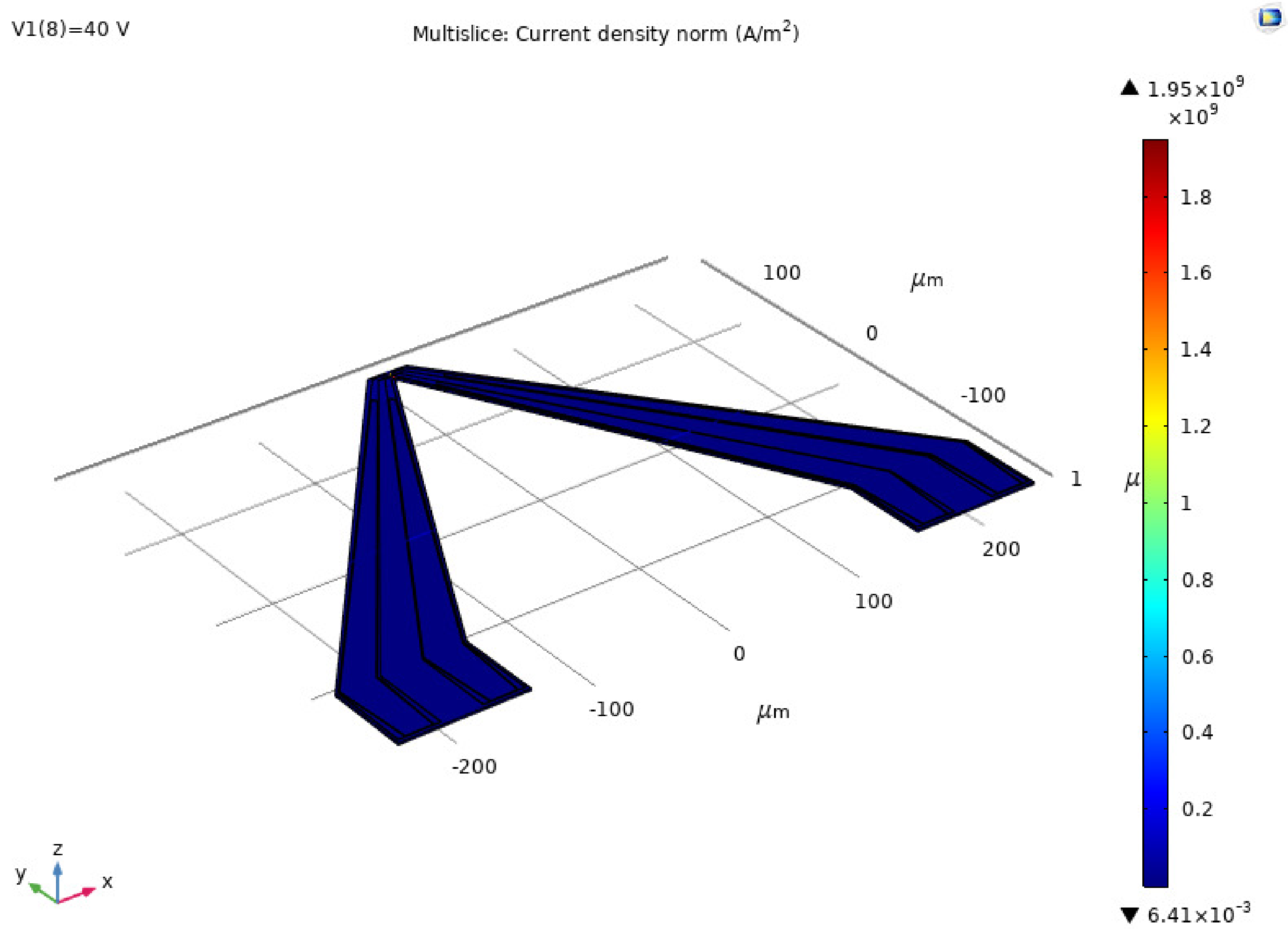

Figure 2 : Current density of the cantilever biased at 10 V

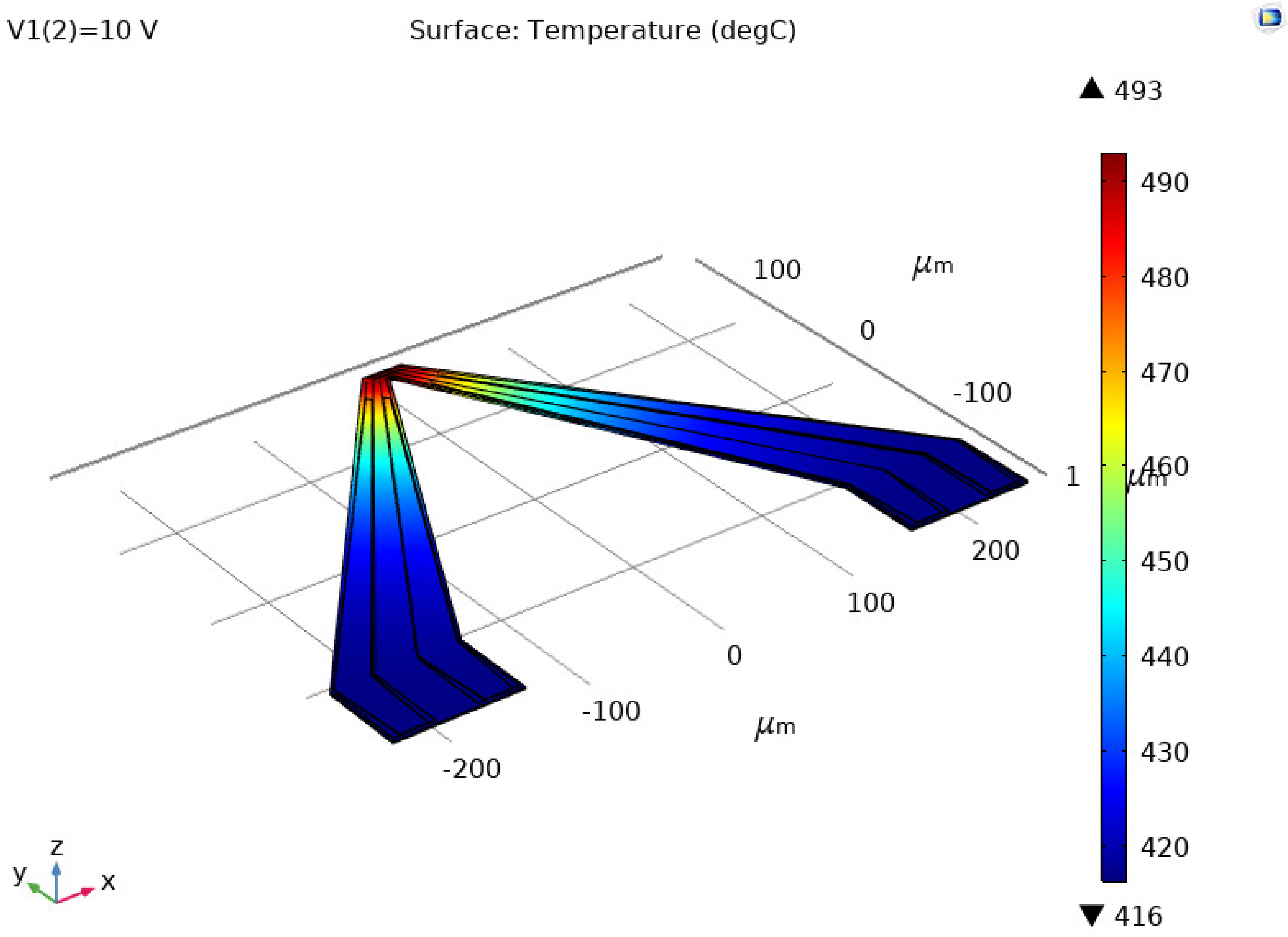

Figure 3 : Temperature profile of the cantilever biased at 10 V