

Fabrication and Characterization of GeO₂/Ge-based MOS Capacitors after Controlled Adsorption of Water Molecules

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The GeO₂/Ge interface is known to generate positive fixed charges upon air exposure, posing challenges for device applications [1]. Our research group has focused on the role of water molecules and their interaction with GeO₂/Ge surfaces. Using *in situ* X-ray photoelectron spectroscopy (XPS) with synchrotron radiated light [2], we systematically studied the relationship between relative humidity and the thickness of the adsorbed water layer (Fig. 1) [3, 4]. We also revealed substantial positive charging of GeO₂ films at humidity levels above 10⁻⁴ %, coinciding with the onset of water adsorption. While this effect was attributed to water penetration into the oxide, possible contributions from X-ray interactions complicated the interpretation.

In this talk, we present an investigation of the charging characteristics of GeO₂/Ge structures pre-exposed to controlled humidity conditions, evaluated through capacitance–voltage (*C–V*) measurements of metal-oxide-semiconductor (MOS) capacitors. To enable these experiments, we developed an integrated reaction chamber capable of annealing, controlled water adsorption, electrode formation via vacuum deposition, and electrical measurements on thermally oxidized GeO₂/Ge samples (550 °C) under high vacuum [5]. As part of the performance assessment of this system, MOS structures were fabricated on GeO₂/Ge structures exposed for 3 h to five different humidity levels (10⁻⁶ %, 0.01 %, 0.1 %, 0.9 %, and 2.0 %) in the reaction chamber, as well as on an as-oxidized reference sample transported in air. The *C–V* curves of samples exposed to 1 % RH or higher, as well as that of the as-oxidized sample, showed hysteresis and a significant negative shift. Furthermore, this hysteresis was identified as injection-type behavior. As shown in Fig. 1, this phenomenon is attributed to the adsorption of water molecules onto the GeO₂/Ge structure [5].

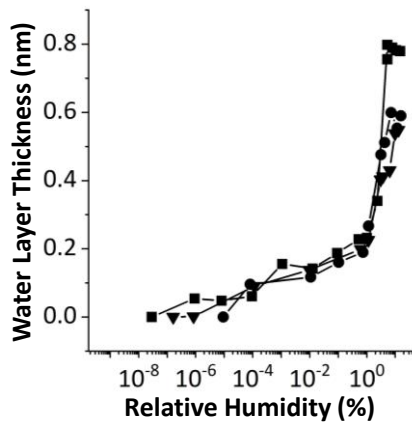


Figure 1. Water layer thickness as a function of relative humidity by *in-situ* XPS.

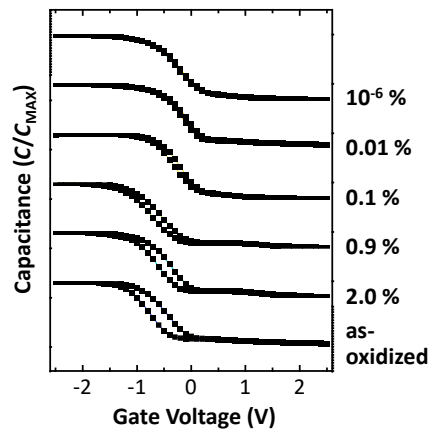


Figure 2. *C–V* curves of samples pre-exposed to each humidity condition.

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- [3] A. Mura et al., J. Phys. Chem. C **117**, 165 (2013).
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- [5] S. Sano, H. Takano et al., J. Appl. Phys. **137**, 155304 (2025).

Supplementary information:

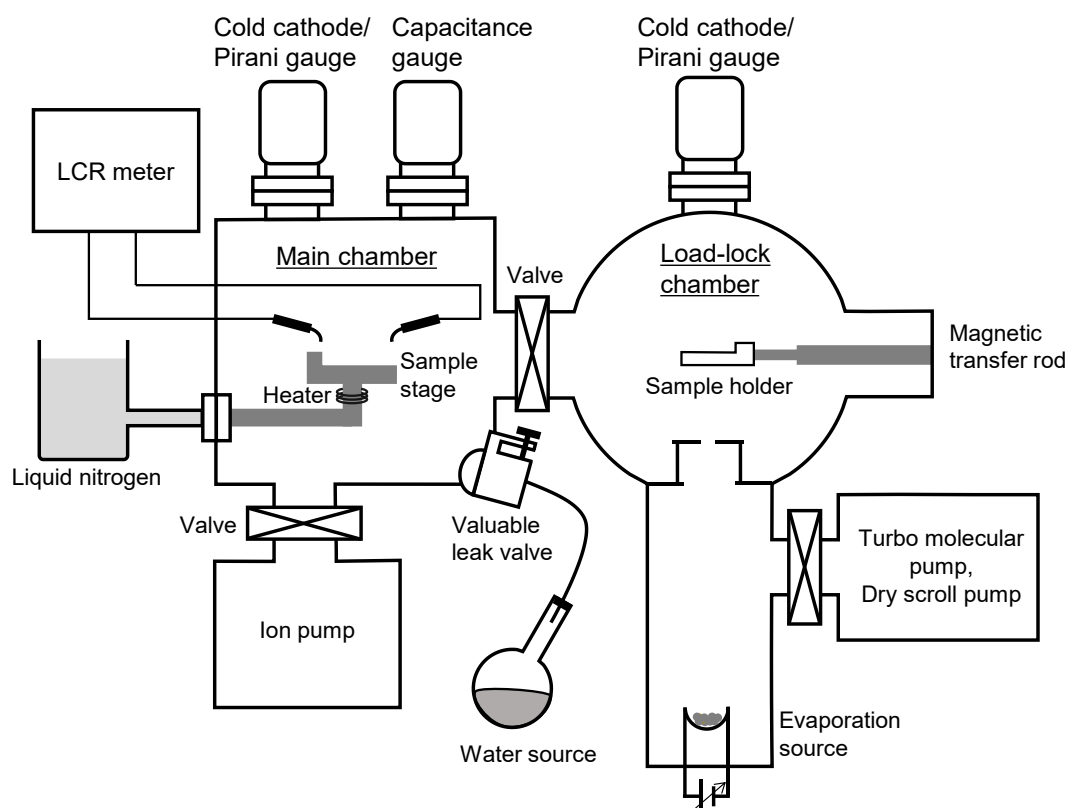


Figure 3. Schematic drawing of our system to measure $C-V$ characteristics of MOS capacitors with water-adsorbed GeO_2 .

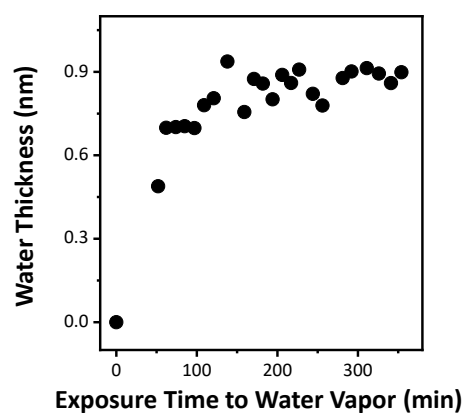


Figure 4. Water layer thickness on this GeO_2/Ge sample as a function of exposure time to water vapor.