Thermal measurement platform: 3ω method

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Context
Measuring accurately the temperature and thermal properties of a sample (solids, liquids, organic, inorganic) has become an important request in the laboratory. The 3ω method [1] that requires a metallic wire patterned on a substrate can be easily implemented in existing devices. The 3ω method is complementary to the optical TD-Thermoreflectance setup available in Nomura Lab, and constitutes a thermal measurement platform for lab members.

Objectives & Methods
This setup aims at being used for nanoscale thermometry from 2D thin films down to in-situ TEM atomic junction. Metallic wires are patterned on a substrate and used as micro heater and temperature sensor. Supplying AC voltage (at ω) on the heater resistance generates a small V3ω signal proportional to the elevation of temperature ΔTh. Under some assumptions, a simplified expression of the thermal conductivity can be extracted from slope of ΔTh versus log(2ω) in the linear region. For in-plane measurement, a second metallic wire is patterned a few microns away from the heater and a second Wheatstone bridge (DC supply) is measuring the elevation of temperature resulting of thermal waves propagation (at 2ω) from the heater.

Results
To validate the electrical setup, the thermal properties of a 125nm thick Si rich nitride membrane have been measured using a fully automated setup from 295K up to 400K in the frame of EUJO-LIMMS project with IMTEK. Such thin film dimension is out of the assumptions for using an analytical expression of the thermal conductivity. We are working on implementing a full 2D physical model using COMSOL simulations.

Fig. 1. Illustrations of the SiN membrane and 3ω full setup.

Fig. 2. Automated measurements of 3ω signals on the heater only.

References