Report for MERTI Internship (Domestic)

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Outline

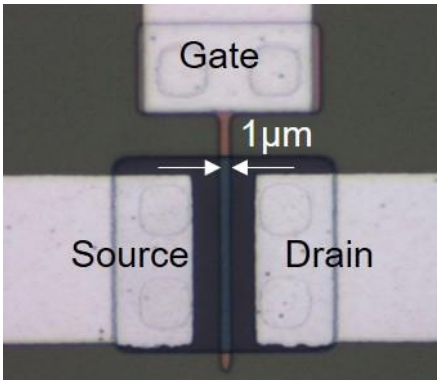
I visited Nanoelectronics Research Institute, National Institute of Advanced Industrial Science and Technology (AIST) from April 1st to July 12th, 2019. I learned basic knowledge of silicon processes and device physics through fabricating metal-oxide-semiconductor field effect transistor (MOSFET).

Background

Silicon devises based on MOSFET is one of the most important technologies in modern electronics. However, its integration density is considered to reach the limit in the future and electronic devices based on new principles have been extensively studied. Our group also investigates "Topological electronics" using topological materials or "Oxide electronics" utilizing a variety of functional properties in oxide materials. However, researchers in the such field are not familiar with silicon technologies and our researches are conducted without understanding modern electronics. The reason I decided to visit AIST is that I would like to review my studies by learning a basic of MOSFET based on the modern electronics.

Contents

I fabricated n-type MOSFET with minimum gate length of 1 μm on p-type bulk silicon wafer utilizing the clean room at AIST. I fabricated the devices by thin film growth such as thermal oxidation, sputtering or chemical vapor deposition and etching processes using hydrofluoric acid or reactive ion etching method. I changed gate electrodes form poly-Si to TiN and investigated how device parameters such as threshold voltage or mobility would be affected.



Optical microscope image of the MOSFET with 1 μm gate length

Even though I fabricated hundreds of MOSFET on one silicon wafer but over 95 %

devices operated as it should. When the gate electrode changed from poly-Si to TiN metal, the threshold voltage shifted to positive direction but the mobility was reduced by a factor of two or three. This may be caused by damage of SiO_2 oxide films by sputtering during TiN growth and a diffusion of nitrogen during annealing process. Improvement of device processes are required to obtain higher mobility device in TiN gate.

Impression

Since my research style in the laboratory is investigating one operating device from several devices, I was amazed to the fact that almost all MOSFETs operated and showed similar properties and also keenly felt the significant differences in our research field and silicon technology. I feel sure that it is good experience to learn the different field from my studies and can overlook my field.

Acknowledgement

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