MERIT Domestic Internship Report

MERIT 8th member (chemistry)

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[Internship site]

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[What I did and the details]

Development of thin film formation process using various raw materials

1.Development of thin film deposition process using chemical vapor deposition (CVD) method for SiN and SiCN

CVD is a process to form thin films by injecting raw chemical materials into a furnace in which samples are placed and conducting chemical reactions in a gas phase state inside the furnace and on the sample surface.

SiN is used as a mask material, insulating film, and barrier film due to its excellent chemical stability. SiCN is used in semiconductor devices and electronics applications due to its high corrosion resistance and insulating properties.

In this internship, experiments were conducted using JAC's CVD equipment to form SiN films with existing material A and SiCN films with new material B. About 35 experiments were conducted under various conditions such as temperature and partial pressure. The dependence of film thickness on spectroscopic ellipsometry and film composition on FT-IR and XPS were investigated. Finally, we showed that fast and stoichiometric SiCN films can be produced using the new raw material B.

2. Development of a thin film deposition process using atomic layer deposition (ALD) of hafnium oxide

The ALD method is a process to create very thin and highly uniform thin films by alternating flow of raw materials for film formation in a single atomic layer. It is used for high-performance solar panels and electronic devices such as memory and CPUs.

Hafnium oxide (HfO_2) is expected to be a high-k (κ) material (high dielectric constant) because of its extremely high dielectric constant of 18 to 25 and good thermal stability. It is expected to be used mainly as a gate insulator in FETs (field effect transistors) in CMOS (complementary metal oxide semiconductors). In addition, HfO_2 is expected to be used as a material for discrete capacitors and silicon capacitors in the future.

Hafnium oxide into the next generation of semiconductors, which are expected to be a few nm or smaller, requires a very uniform process such as ALD, but the search for the raw materials is still

ongoing due to high-speed growth, raw material costs, and other factors.

In this internship, I will improve JAC's ALD system and conduct about 35 experiments on existing material C and new material D under various conditions such as temperature and feed partial pressure. and investigate the dependence of film thickness using spectroscopic ellipsometry and film composition using FT-IR and XPS for the resulting thin films. We investigated the dependence of film thickness using spectroscopic ellipsometry and film composition using FT-IR and XPS, and proposed conditions for a better process.

3. Thin film deposition using ALD method for BN

In this internship, we also conducted an experiment to apply a BN (boron nitride) film uniformly in a complex structure such as a trench or pit. BN has excellent features such as high heat resistance, low dielectric constant, and low friction. The ALD method described above was used because it was necessary to apply a very thin film uniformly. We confirmed that a BN film with the desired thickness was successfully formed.

In addition, I observed a process using plasma ALD/CVD.

[ALD/CVD things that I learned in this internship]

A. Efficient determination of experimental conditions for process development and facilitation of work in experiments

In order to search for raw materials, it is essential to conduct experiments to confirm whether or not membranes can be produced, but it is necessary to conduct as few experiments as possible while still being able to pick up as much necessary information as possible. I believe that I was able to conduct more efficient experiments during this internship as I became more accustomed to the work and as I learned more about what I was doing. I am also glad that I was able to think about how to facilitate as many experiments as possible within the time frame.

B. Understanding of equipment and methods for modifying and repairing equipment

Under the guidance of JAC employees, I was able to perform the maintenance and modifications necessary to conduct experiments and perform appropriate post-processing on CVD and ALD equipment and piping from the equipment to the air intake and exhaust systems, and I believe that we gained skills in this area. I also gained an understanding of the structure of CVD and ALD equipment, as well as the valves and other components necessary for the equipment, as I needed to understand the equipment.

[At the internship site / Acknowledgements]

During this internship, I was treated very kindly by the employees of JAC. I was able to concentrate on research and development, and they provided me with very kind guidance. Thank you very much for accepting me. The skills that I learned in the MERIT program, such as research execution and presentation of results, were utilized to maximize results within the company and to share progress more efficiently, and my ability to look at things from a bird's eye view was extremely useful when I was aware of the connection between my research at the university and my research at JAC.