

Report for MERIT-WINGS internship (domestic)

Department of Electrical Engineering and Information Systems, Tanaka Laboratory

First year of doctoral program, 12th MERIT student

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1. Overview

- Duration

2024/11/5-2024/11/29

- Location

Tokyo Electron Technology Solutions Corporation, Simulation Technology Development
Department

- Research topic

Process simulation of semiconductor manufacturing equipment

2. Overview of the internship

This internship was conducted face-to-face at the Hosaka Office of Tokyo Electron Technology Solutions Corporation in Nirasaki City, Yamanashi Prefecture. I applied for the internship after participating in the MP-CoMS-sponsored Workshop on Matching the Needs of Companies for Human Resources with the Seeds of Human Resources for Doctoral Degrees. At the internship meeting, we discussed themes that I, as a member of an experimental laboratory, could also do in the simulation development department. During the internship, I had the opportunity to attend lectures on the knowledge required for simulations and to observe the semiconductor manufacturing equipment that Tokyo Electron is currently developing. The results briefing is scheduled to be held the month after the internship ends, with Tokyo Electron members and a professor of my laboratory in attendance.

3. Research contents

3.1. Background

In recent years, high-k materials have been used as gate insulating films for semiconductor devices. Tokyo Electron has developed three types of ALD equipment for high-k materials: single wafer, semi-batch, and batch. Film deposition simulation for each type of equipment is essential for improving film quality. However, there is no track record of film deposition simulation for high-k materials on single wafer ALD equipment. Therefore, the aim of this internship was to support equipment and process development by analyzing the gas behavior inside the equipment using thermal fluid analysis that includes reactions in the single wafer ALD equipment.

3.2. Method & Results

We mainly worked on two themes. In the first theme, we created an analysis model of an ALD device and conducted a thermal fluid analysis with the source gas flowing in as in the actual process. We compared the calculation results with the experimental results and examined the temperature dependence of the film thickness and in-plane variation. We found that, under high-temperature film formation conditions, reactions not intended by ALD were occurring, causing the film thickness to increase. In addition, by adjusting the coefficients of the chemical reactions, we were able to bring the temperature dependence of the film thickness closer to the experimental results.

In the second theme, we considered the effects of thermal decomposition of the source gas. First, we confirmed the temperature, pressure, and gas flow rate dependence of the decomposition reaction. Then, we incorporated the thermal decomposition reaction into the model created in the first theme and performed thermal fluid analysis. As a result, it was suggested that thermal decomposition progresses on the outside of the wafer, and that this may affect the variation in film thickness within the wafer.

4. Impression

During this internship, I carried out thermal fluid simulations, including chemical reactions, for the deposition of high-k materials on single wafer ALD systems. As I had no previous experience of simulations, I didn't know what to do at first, but thanks to the generous support of the member in the Simulation Technology Development Department, I was able to gain a lot of knowledge. I was also able to experience the differences between university research and corporate research, which was useful for choosing a career path. Furthermore, communicating with various people was a valuable experience that allowed me to gain a deeper understanding of the company.

5. Acknowledgements

I would like to express my gratitude to everyone at Tokyo Electron Technology Solutions Corporation for giving me the opportunity to undertake this internship. I would also like to express my deep appreciation to Mr. Matsukuma, the General Manager of the Simulation Technology Development Department, for his cooperation and support in organizing this internship; to Ms. Hosaka of the Human Resources Department, who provided me with various support in my daily life; and to Mr. Monden, Mr. Miyatani, Mr. Uki, Mr. Aita, Mr. Jo, and all the other members of the Simulation Technology Development Department, who provided me with direct guidance. I would also like to thank Professor Masaaki Tanaka, and Professor Eiji Saito, for approving this internship. Finally, I would like to thank the MP-CoMS and the MERIT program for providing me with this wonderful opportunity.