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A Study on Mixed Circuit Modeling and Simulation Using Education Modelica Language

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Abstract. The current industry integrates various fields, however, simulations tools are not compatible as they are limited to individual systems. Spice stimulation tool, previously used in existing electronic circuit simulations, cannot easily teach how the transistor model operates because the transistor model appears as a black box. However, if one uses the Modelica, the alternative circuit of transistor can be visual, and students can select and explore the different levels of the model. Using this modelica language, the actions of modelica were confirmed through simple electronic circuit, and the modeling and simulation for gas reaction tank system were performed as an example of a multi-domain model. This will become an effective training tool to teach basics of semiconductor technology. Therefore, it can serve as an excellent vehicle for communicating the knowledge of the dynamic system among scientists and engineers.

Keywords: Modelica, Modeling, Mixed Circuit, Simulation, Semiconductor Manufacturing

1 Introduction

Computer simulation is widely used for product optimization and to shorten the time and cost of product development. In past simulations, it was considered to be effective to divide one big system into detailed systems. However, it has developed into the direction of performing multi-dimensional complicated simulations including detailed systems such as machine, electricity, materiality and thermodynamics.

The simulation softwares used before the development of Modelica language had outstanding performance in the domain considered as a strength of the software. However it had less competitiveness in modeling components of other domains. For instance, SPICE shows good performance in simulating electronic circuits, but there are limitations when students use SPICE to make simulation for the annual rainfall. Modelica simulation language, which was designed to overcome such limitations, define components using equations, and its principle is to make modeling easy and reusable. Therefore, using Modelica, students can perform more delicate simulations covering the whole process from the transistor circuit to manufacturing.

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2 Purpose and Methods of Research

The current industry integrates various fields, however, simulation tools are not compatible as they are limited to individual systems. Modelica can be applied to simulations for various fields and can be used in a mixed form. Simulink does not allow students to intuitively distinguish the types of circuits as the results are displayed in block diagrams. On the other hand, Modelica has strength in interpretation as each component is visualized to be easily understood. Mixed systems such as semiconductor manufacturing use many complicated equations, and Modelica is based on equations, which makes it unproblematic even if the equations are very complicated. It conducts mixed circuit modeling and simulation applying various elements to the electronic circuit, and makes effective simulation possible through compatibility with other simulation libraries.

Previous studies expressed results with block diagrams using Simulink for the modeling and simulation of DC motor. To express this, one needs to construct formulas and even if it has been expressed, it is difficult to understand the circuit intuitively. In this study, Modelica has been used for the modeling and simulation of DC motor to form the circuit more easily and understand it intuitively.

In an existing study on the electron-beam lithography, which is a process of semiconductor manufacturing, CASINO was used for modeling and simulation. It suggested that simulation can be performed with Modelica, and one can expect more compatibility with other systems using Modelica.

3 Research Background

Convergence is a general phenomenon rapidly spreading among all areas such as social studies, culture, politics and economics, and it is the most important trend of the 21st century. Convergence is a phenomenon where the boundaries between two or more fields disappear, and two or more technology and functions are integrated among different fields. Based on technology development, this phenomenon of convergence is accelerating with the changes in market and consumer needs, and company needs. From the technology aspect, component technology such as system on chip (SOC), which is a system with various systems integrated into one chip; convergence software and convergence service technology are being developed. From the market aspect, the demands for convergent products and services, which integrates independent functions into one product, are increasing. Companies have understood that the existing one type industry or product is not competitive in the market. Consequently, in order to adapt to the changes in technology and market environment, companies are converging not only products but also business areas. [1]

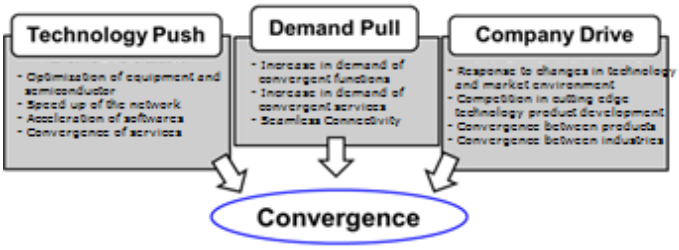

Fig. 1. Acceleration Factors of Convergence

4 Modeling and Simulation of the Gas Tank System

Numerous gas pipes go through the interior of the semiconductor production line. In these pipes, other gases are included and they are all used for semiconductor manufacturing. For example, among the eight steps of semiconductor manufacturing, there are manufacturing processes for CVD and Diffusion, which forms a thin film on the surface of wafer by creating chemical reaction.

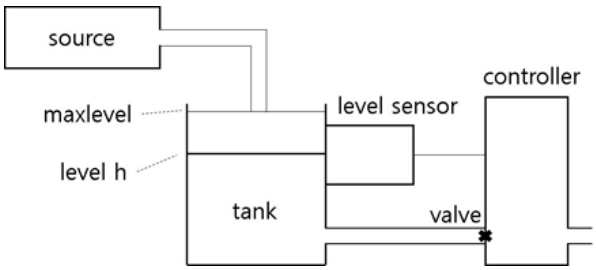

Fig. 2. Gas Tank System

The gas tank system used for manufacturing shown in Fig. 2. is composed of a source, which supplies the gas; a tank, which stores the gas; a sensor, which senses the gas within the tank; and a valve, which controls gas emission. The gas tank system was modelled with Modelica, and simulation was performed to produce a gas reaction graph influenced by the changes in amount of gas and the chemical reaction of gas. The modeling process is as follows. The modeling was largely divided into gas reaction system and tank system. First, the variables and parameters needed for the internal controller of the gas reaction system and tank system were set. In the tank system, the amount of gas entered and emitted through the valve was conceptualized as the changes in gas within the tank interior, and formed into a formula. For example, the gas reaction was modelled as the reaction of H and I; for each models the initial concentration was designated; and the amount of gas that is formed by the reaction of gas amounts entered and emitted was expressed with a formula related to the gas reaction system.

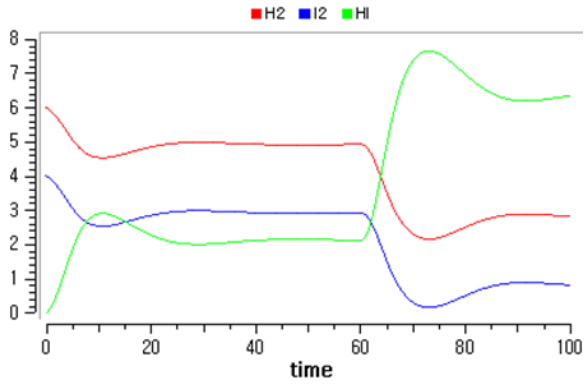

Fig. 3. Simulation results of the gas reaction system

Fig. 3. depicts the simulation results of the gas reaction system. It shows that as gas H2 and I2 reacts, the amount of gas gradually decreases and the amount of gas H1, which is created by the reaction, gradually increases. After time 60, as the gas in the tank is restored by the source and a large reaction occurs once more, the amount of gas H2 and I2 decreases and H1 increases once more.

5 Conclusion

In this study, the modeling and simulation was performed for the gas reaction tank system. The semiconductor line has numerous gas pipes, and various gases are used in the semiconductor manufacturing process. The amount of gas within the tank and the amount of gas created by reactions can be examined in graphs. Modelica, which is suitable for multi-domain modeling and complicated equations, is convenient for modeling semiconductor manufacturing, which is composed of various processes and equipments. To make electronic circuit modeling and simulation, a simulation tool specifically developed for electronic circuits should be used; and to make machine modeling and simulation, a simulation tool for machines should be used. In other words, for simulations of different fields, different simulation tools should be used. However, by using Modelica, one does not have to use different simulation tools for modeling and simulation of different fields. Through Modelica, researchers of different fields will be able to freely exchange their models and this will make it easier for them to conduct research in collaboration.

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