論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Study of Quartz Crystal Microbalance behavior with viscous sensing film and its interpretation using Mason equivalent circuit
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出典(和文)	学位:博士(学術), 学位授与機関:東京工業大学, 報告番号:甲第12011号, 授与年月日:2021年3月26日, 学位の種別:課程博士, 審査員:中本 高道,山口 雅浩,中村 健太郎,長谷川 晶一,吉村 奈津江
Citation(English)	Degree:Doctor (Academic), Conferring organization: Tokyo Institute of Technology, Report number:甲第12011号, Conferred date:2021/3/26, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	Information and communication Engineering 系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of (Philosophy)

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要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words)

The unusual positive frequency was uncovered by our interpretation using Mason equivalent circuit. With the boundary of viscous film, our model covers the thickness range from thin film to bulk liquid loading. The highly robust measurement system based on VNWA(Vector Network Analyzer) was also fabricated. The measurement setup made up of QCM coated with viscous film and microdispenser were developed to realize simulated sensor sorption with controlled precision.

Our measurement system was developed based on VNWA. The conductance curve fitting technique in real-time which utilizes all data from the VNWA frequency sweep was developed. Further noise reduction was obtained by the Savitzky-Golay filter. The noise performance and detection limit of the developed system was evaluated using an aqueous glycerol solution. Savitzky-Golay filter parameters were also optimized so that small change of glycerol concentration could be detected. The independent t-test was used to check whether small concentration change could be significantly detected.

Further setup of a micro dispenser and QCM holder was adopted and combined with the measurement system. The purpose of using microdispenser is to imitate analyte molecules deposited on QCM. The experiment was conducted on microdispenser to determine deposition volume. The QCM holder was designed to fixate the dispenser tip location relative to QCM electrode. The dip coating method was used to coat QCMs with film materials. A bare QCM experiment was conducted with various substances. PEG20M represents rigid film, where the experimental results agreed well with Sauerbrey's equation. Water and glycerol dissolved in acetone were also tested until frequency change saturated. Lastly, the QCMs coated with PEG20M, PEG2000 and Glycerol were deposited with water. The result shows positive frequency occurred with PEG2000 film when deposited with water.

The simulation using Mason equivalent circuit model with the parameters of glycerol and water frequency agreed with Kanazawa's equation at large film thickness. Also, the two-layer simulation was investigated using a parameter of glycerol as a base layer and water as a top layer. Then, the application of the developed model to estimated film thickness and viscosity from experimental results was also investigated with the water and glycerol deposition. However, the positive frequency shift could not be observed in the experiment.

Our developed viscous film model predicts that positive frequency shift occurs within the certain range of film thickness at the condition of constant viscosity. We further expanded this model to the condition of varying both viscosity and film thickness, obtaining the surface plot of frequency and resistance changes. Thus, the combined contour plot of both frequency and resistance changes was drawn for better visualization and it can predict some tendency of response from experimental data.

We qualitatively interpret the water deposition over viscous films with the assumption that the water sorption causes the overall film thickness to increase and the film viscosity to decrease. This assumption is expected to be able to adequately explain the experimental data so that the Mason circuit model can work. We found that both negative frequency changes from PEG20M and unusual positive frequency change from PEG2000 can be explained on contour plot with the assumption of film thickness to increase and the film viscosity to decrease after water sorption.

This study aims to reveal the unusual behavior of QCM both theoretically and experimentally. Firstly, we proposed Mason equivalent circuit model to interpret QCM behavior with viscous coating. The simulation of our model suggested that a positive frequency shift could occur at certain film thicknesses at a constant viscosity. Next, we developed the measurement system based on VNWA to tackle the problem of signal deterioration in highly viscous media. Noise level and detection limit were much improved compared with the conventional system. Lastly, the experiments were conducted by coating the QCMs with various

films and depositing water over the films using a microdispensor, to reproduce a positive frequency shift response from QCM. Mason equivalent circuit can roughly explain the QCM behavior of both positive and negative frequency shift with the assumption of viscosity decrease and film thickness increase after water depositions. This study has revealed the mechanism of positive frequency shift under highly viscous environment, which has been unclear for long time in the field of acoustic wave chemical sensor.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note：Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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