Micro Environment Simulation of Microscopic Fluid Chip System Applied to Scanning Electron Microscopes

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Abstract

Micro environment Simulation in the Microscopic Fluid system can provide lots of information such as cells culture or bacteria split inspection in biological application, nanoparticle distribution in liquid status, electrochemical deposition in material science, and in-situ etching process inspection. The values of SEM can be boosted by introducing the Microscopic Fluid Chip system with continuous buffer liquid piping, thermal control, gas mixture and real-time monitoring to create micro environment simulation. In this paper, the performance was validated by a microflow calibration system and a simulated SEM vacuum chamber. Eventually, the dynamic images of gold particles and in-situ etching process were captured by integrating microscopic fluid chip and SEM.

Introduction

Micro environment Simulation of Microscopic Fluid Chip system with liquid sample image in SEM can provide many unique point of view into different areas, such as materials science, biological application, electrochemical reaction, energy storage, food analysis, etc. In materials science, the applications of nanobubbles have been an important topic in recent years, some researchers observed the generation of hydrogen nanobubbles in KLH protein liquid solution under electron microscope. In electrochemical deposition, some groups discovered the changes of polypyrrole film thickness caused by redox reaction of the film, oxidation-reduction and electrochemical deposition of silver. [1] In biological application, it can be used in cells containing labelled proteins like Labeling of COS7 Cells with EGF-QD [2] biological activity in cells, such as striking combination of whole-cell morphology with a wealth of internal details and demonstration of the fully hydrated yeast cell in the native intracellular structure [3]. Briefly speaking, it’s quite important to understand the processes in morphological changes and undesirable structural under molecular level on living state and native liquid environment. Furthermore, with the continuous flow control, thermal control and real-time monitoring, the long-term operation can be achieved and also expand the applications of the microscopic fluid chip with making high resolution in situ imaging.

Micro environment Simulation of Microscopic Fluid Chip system design

Micro environment Simulation of Microscopic Fluid Chip system consists of a microscopic fluid chip stage, microflow and thermal control system. In Fig. 1, the Microscopic Fluid Chip stage design was based on computer simulation and laminar flow theory. It has a sandwich-like structure and embedded 20 nm thin film that was tested in the SEM simulated vacuum chamber. The pressure inside the stage is very critical because the flowrate needs to be maintained in less than 0.2 mL/h in order not to break the thin film. It also unique substrate contain holder design. After the optimization of the Microscopic Fluid Chip system design was achieved, it was tested by microflow calibration system with different flowrates (Fig. 2). At the meantime, the results observed by SEM image showed that the thin film stayed complete even the flowrate were increased up to 120 mL/h. With regard to the thermal control system as shown in Fig. 3, a preheating system of buffer liquid was developed by using a thermal control module. In addition to the preheating system for the buffer liquid, an embedded TEC (Thermoelectric Cooling Chip) was also designed inside the Microscopic Fluid Chip system with the capability of fine-tuning so as to achieve accurate and rapid temperature control. Furthermore, several design parameters including long working life, noiseless and non-vibration were also considered for the thermal control system. After preliminary experiments, the heating rate inside the stage can be achieved to 3.7 ℃ per minute.

Results and Discussion

Eventually, the microflow and thermal control systems were integrated and it reveals the capability of the microflow and thermal system in the biological 、material and energy application. With the microflow and thermal control modules integrated in SEM, the flowrate and fluid temperature can be adjusted by the users and the flow conditions including temperature, the fluid properties can be simultaneously monitored as well. Finally, the Microscopic Fluid Chip system demonstrates its great capability in SEM and provides the in-situ etching process in the liquid and temperature controlling environment as shown in Fig.4

References

[1]Satoshi Arimoto. Electrochimica Acta: Development of new techniques for scanning electron microscope observation using ionic, **Volume** 53, Issue 21, (2008).

[2]N Jonge, DB Peckys. National Agricultural Library. Washington, DC (USA): Electron microscopy of whole cells in liquid with nanometer resolution No. 7, p. 2159-2164, (2009).

[3]Diana B. Peckys. Biophysical Journal : Fully Hydrated Yeast Cells Imaged with Electron Microscopy, **Volume** 100, Issue 10, (2011).

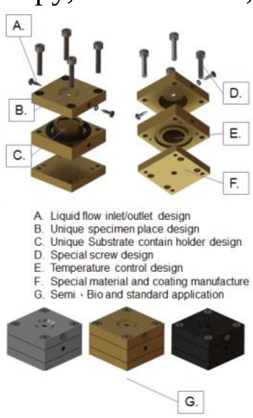

Figure 1. Microscopic Fluid Chip Stage

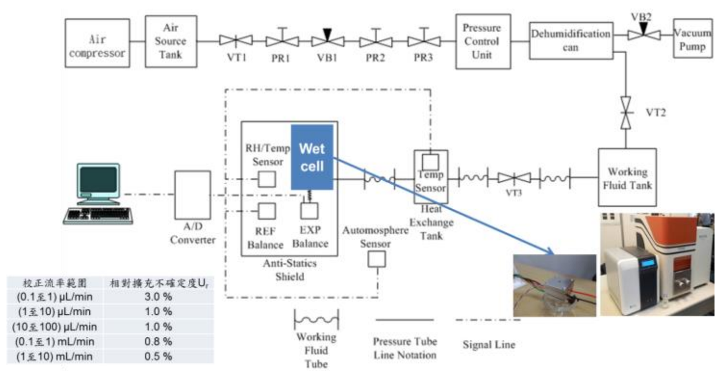

Figure 2. Microflow system

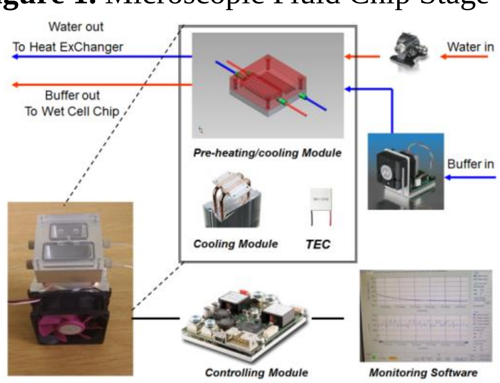

Figure 3. Thermal system

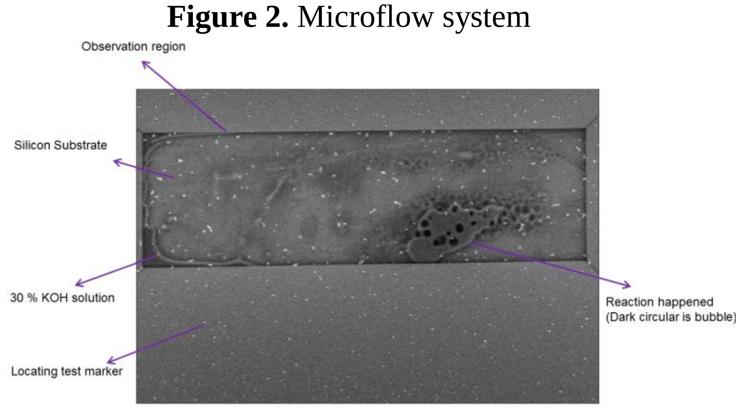

Figure 4. In-situ etching process