102 Overview: Recent Topics on Micro Visualization in Japan

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ABSTRACT

Micro technology is one of the key technologies in advanced engineering of various fields. Analysis of micro scale thermal and fluid dynamics is also important factor in the development of micro technology, such as flow around micro machine, micro-fluidic, micro heat exchanging system, micro chemical and bio-medical analysis system, and so on. Though the micro scale visualization is accompanied by some difficulties caused by the scale effect, it is effective in order to understand phenomena in micro scale flow. Recent topics on the method of micro flow visualization and applications in Japan are summarized.

Keywords: Micro Scale Flow, Micro Visualization, Micro Channel, Micro PIV

1. Introduction

Technology for manufacturing of large-scale integrated circuit and peripheral devices for computer was playing important role in the development of micro scale technology. Recently it has been extended into various fields of engineering, such as MEMS (Micro Electro Mechanical System), Bio-MEMS, micro machine, micro heat exchanger for cooling of micro scale devices, microchip for chemical and bio-medical analysis, μ -TAS (Micro Total Analysis System), micro scale medical instruments, and so on. In the micro technology, thermal and fluid dynamic phenomena are important factor in practical design. Therefore new development of qualitative and quantitative techniques of micro scale visualization of thermal and fluid dynamic phenomena in micro scale is required.

For the investigation on fundamental technology of micro scale thermal and fluid dynamics and its practical application, some workshops have been organized in Japan. For example, Research and Investigation Subcommittees on Experimental Fluid Dynamics (EFD) (1994-1996), on Micro EFD (1997-2000), and on Flow and Heat Transfer in Micro Channel (1997-2001) were organized by Japan Society of Mechanical Engineers (JSME). Research and Investigation Committee on Application of Micro Channel was organized by Micromachine Center. In Visualization Society of Japan (VSJ), the workshop on Micro Visualization has been organized in 2000. Some explanation articles on micro scale thermal and fluid dynamic phenomena have been published in Journal of JSME, Journals of Japan Society of Fluid Mechanics (JSFM), Journal of VSJ, etc. And also many papers of research on micro scale thermal and

fluid dynamics have been presented in annual meetings of JSME, JSFM, VSJ, Heat Transfer Symposium and so on.

Recent topics on micro scale visualization techniques and applications in Japan are surveyed.

2. Visualization Techniques and Applications

There exist a variety of techniques for imaging or measuring the shape of materials with micro scale resolution. Optical microscopy is one of the most common techniques, where light reflected or emitted from a specimen is imaged. This technique can be applied to qualitative and quantitative observation of micro scale thermal and fluid dynamic phenomena. The microscope observation has optical restriction in the arrangement of specimen with complicated configuration. In the case that observation distance, i.e., the distance between the object lens and the specimen, must be long in the range of 10~50mm, it can be realized by using a combined system of camera and high powered macro lens.

Micro PIV constructed with microscope or macro lens system is one of the common techniques of quantitative measurement of micro flow field, and its basic problems and applications have been investigated. Brownian motion effect on velocity measurement of flow in microspace by PIV technique was investigated by microscopy using sub-micron fluorescence particle⁽¹⁾. Fundamental characteristics of particle imaging in micro PIV applications by different optical systems were investigated by practical applications of velocity measurement in micro channels⁽²⁾⁽³⁾⁽⁴⁾. And also micro PIV has been applied to analyses of physical properties and phenomena of flow in microspace. The effect of gas-liquid interface on micro channel flow⁽⁵⁾, the drag

reduction in wall-bounded turbulent shear flow in micro channel⁽⁶⁾, the blood flow in microcirculation⁽⁷⁾, the micro flow around rotating particle induced by optical pressure⁽⁸⁾, the motion of toner particles in electrophotography⁽⁹⁾, Brownian motion and chain-link cluster of ferromagnetic particles⁽¹⁰⁾⁽¹¹⁾ and the electroosmotic flow in micro channel have been analyzed by using micro PIV technique. Feasibility of 3D velocity measurement of micro channel flow by SPIV (Stereoscopic PIV) has been examined⁽¹²⁾.

Micro visualizations on physical quantities except velocity have been also investigated. For example, two-dimensional temperature field visualization in micro channel within spatial resolution $5\mu\text{m}\times 5\mu\text{m}$ ⁽¹³⁾, micro scale temperature visualization by using scanning thermal microscopy⁽¹⁴⁾, and visualization of surface shear stress by using micro sensor array⁽¹⁵⁾ have been reported.

And also there are many reports on micro visualization by conventional techniques and by numerical methods for analysis of thermal and fluid dynamic phenomena. These are visualization of mixing and chemical reaction on a micro-fluidic device⁽¹⁶⁾, visualization of micro thruster operation⁽¹⁷⁾, visualization of bubble behavior in heated micro channel⁽¹⁸⁾, visualization of flow in micropump driving by boiling propagation phenomena induced in a micro channel⁽¹⁹⁾, visualization of thermal fluid phenomena induced in a micro vaporizing chamber with a nozzle⁽²⁰⁾, development of new method of numerical visualization for micro channel flow⁽²¹⁾, numerical visualization of flows in micropump⁽²²⁾ and so on.

3. Conclusion

Recent activities of research on micro visualization in Japan are summarized. However, it is not all. The investigations published and presented mainly in the journals and proceedings of Japanese societies relating thermal and fluid mechanics are introduced. Micro visualization will become important more and more for development of micro technology in various engineering fields. For the future development, the international collaboration and network of research on micro visualization must be desired.

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