Imaging Flow, Transport, and Mixing in Microflows Using Molecular Tagging Diagnostics

Manoochehr Koochesfahani*, Chee Lum*, Shahram Pouya*, and Hui Hu†

* Department of Mechanical Engineering
Michigan State University
East Lansing, MI 48824, USA
koochesf@egr.msu.edu

† Department of Aerospace Engineering
Iowa State University
Ames, IA 50011, USA

Molecular tagging diagnostics take advantage of molecules that can be turned into long lifetime tracers upon excitation by photons of an appropriate wavelength. Typically a pulsed laser is used to “tag” the regions of interest, and those tagged regions are interrogated at successive times within the lifetime of the tracer. Molecular tagging methods have been increasingly used for velocimetry in macroscopic flows because of the advantages they can offer over particle-based techniques in situations where the use of seed particles is either not desirable, difficult, or may lead to complications [1].

The most common tools currently used for the in-situ imaging of microflows are largely particle-based techniques (e.g. microPIV). Since the fluid motion is not measured directly but is inferred from the motion of particles, the interpretation of results needs to account for the potential interaction of particles with walls and the complications arising from electrothermal and electrophoretic forces. These constraints can be eliminated in molecular-based flow imaging techniques.

In this paper we present recent developments in the quantitative imaging of microflows using molecular tagging methods. Both pressure- and electroosmotically-driven flows are considered [2]. A water-soluble phosphorescent compound is used as the molecular tracer. Results will be presented from in-situ measurements of velocity profile and wall shear in a pressure-driven flow. Electroosmotically-driven flows involve additional complications, e.g. presence of an electric field and a time-varying temperature field caused by Joule heating. Since the molecular tracer used here is not charged, it faithfully tracks the motion of the carrier neutral fluid even in the presence of an electric field. Results will be shown from simultaneous measurements of velocity and temperature within a microchannel for different applied potentials.

A new generation of “molecular” level diagnostics is also being developed based on quantum dots (QDs) with a potential to open new avenues for exploration of flows at the micro and nano scales [3]. This paper will present the unique properties of these diagnostics that make them extremely attractive for fluid flow studies.

References

[1] M.M. Koochesfahani (Ed), Special Feature: Molecular Tagging Velocimetry, *Meas. Sci. Technol.*, **11(9)**, 1235-1300, 2000.

[2] C. Lum, “An experimental study of pressure- and electroosmotically-driven flows in microchannels with surface modifications,” Ph.D. thesis, Michigan State University, 2005.

[3] S. Pouya, M. Koochesfahani, P. Snee, M. Bawendi, and D. Nocera, “Single quantum dot (QD) imaging of fluid flow near surfaces,” *Exp. Fluids*, **39(4)**, 784-786, 2005.

Keywords: microflows, molecular tagging, quantum dots