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QUANTITATIVE VISUALIZATION TECHNIQUES FOR MULTIPHYSICS AND MULTISCALE MEASUREMENTS IN MICROFLUIDICS

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KEYWORDS:

Main subjects: multiphysics and multiscale quantitative visualization
Fluid: liquid and/or gas flow
Visualization method(s): functional particles, μ-PIV, μ-LIF, PSP
Other keywords: micro/nano hybrid PIV, oxygen sensitive film/particle

ABSTRACT: Quantitative visualization techniques for multiphysics (e.g. simultaneous measurement of velocity and concentration fields) and multiscale (e.g. micro and nano scale) measurement techniques in microscale flows are addressed in this lecture. The conventional two-dimensional (2-D) micro particle image velocimetry (micro-PIV) technique has inherent bias error due to the depth of focus along the optical axis to measure the velocity field near the wall of a microfluidics device. However, far-field measurement of velocity vectors yields good accuracy for micro-scale flows. Nano-PIV using the evanescent wave of a total internal reflection fluorescence microscopy (TIRFM) can measure near-field velocity vectors within a distance of around 200 nm from the solid surface. A micro/nano hybrid PIV system is proposed to measure both near- and far-field velocity vectors simultaneously in microfluidics. A near-field particle image can be obtained by a TIRFM using nanoparticles, and the far-field velocity vectors are measured by three holes defocusing micro particle tracking velocimetry (micro-PTV) using micro-particles. In order to identify near- and far-field particle images, lasers of different wavelengths are adopted and tested in a straight microchannel for acquiring the 3 dimensional 3 component (3D3C) velocity field. We found that the new technique gives superior accuracy for the velocity profile near the wall compared to that of conventional micro-PIV. This method has successfully applied to precisely measure wall shear stress in 2-D microscale Poiseulle flows. A planar optode system based on the oxygen quenchable luminophore platinum (II) octaethyporphrin (PtOEP) bound with thin polystyrene (PS) film and UV light-emitting diodes (UV-LEDs) was developed to measure the dissolved oxygen (DO) concentration field in microscale water flows. An intensity-based method adopting a pixel-to-pixel *in situ* calibration technique was used to measure DO concentration fields around an impinging micro jet. The achievable spatial resolution of the acquired concentration map could be as high as 3.0 μm. A micro round water jet having 100% of DO was obliquely impinged on to a PtOEP/PS film coated plate placed in a 0% of DO water container. It is demonstrated that the high DO concentration region was coincided with the impingement area. The DO concentration gradient due to DO diffusion was affected by Reynolds number. Oxygen sensitive particles (OSParticles) are developed to measure velocity and dissolved oxygen (DO) concentration fields in microscale water flows. The functional particles are fabricated by a dispersion polymerization method using an oxygen quenchable luminophore (PtOEP) doped PS polymer. A pulsed UV light-emitting diode (UV-LED) illumination system is developed to measure the DO concentration of the particles and the μ-PIV method is used for velocity field measurement. An intensity-based method adopting a modified pixel-to-pixel in situ calibration technique is used to quantify DO concentration fields in a Y-shaped micro channel. The diffusion process of DO through the interface between two parallel water flows having different DO concentrations was quantitatively measured with velocity field in the microchannel.he accuracy of data analysis methods were compared between intensity based measurement technique and lifetime based measurement technique.