Micro-Imaging System Specification

REQUIREMENT:

Code 6180 has a requirement for a Micro-Imaging System (SYSTEM) for measuring flow, chemical transport, chemical environment, and species identity on a micrometer scale relevant to a number of areas including microfluidic devices and biological systems. In this Requirements Document unless otherwise stated, the term fluorescence will refer to laser induced fluorescence emission of species in the imaged field as opposed to the emission from any added particles/spheres used for velocity marking.

SPECIFICATIONS:

1) MICRO-IMAGING SYSTEM

The contractor shall provide a Micro-Imaging System (SYSTEM) to include a fully motorized 3-axis, precision controlled microscope stage; suitable microscope objectives, lenses, and optical wavelength filters to cover a range of magnification and emission wavelengths; camera and imagining components capable of making high resolution images in real time; image capture and processing software that can provide flow-field velocity information, component concentration, temperature, pH and particle/structure/shape/size information.

The SYSTEM must have a minimum of two cameras: one camera optimized for deriving velocity information and a separate camera optimized for imaging species fluorescence. The SYSTEM must record images for velocity derivation and fluorescence from the same sample image field simultaneously or with minimal time difference between image acquisition and without the need for configuration, lens, filter or other optics changes or realignment of the laser, sample, or imaging systems. The optimum system would be able to record both velocity images and fluorescence images at a data collection frequency ≥ 2 Hz.

The SYSTEM must exhibit maximum versatility and configuration flexibility for a research instrument from the light sources and their coupling into the microscope to the microscope and stage configuration.

The SYSTEM must provide for a range of working distances and varying sample configurations (flexible sample access and mounting).

The SYSTEM must meet or exceed the above general requirements and the specific requirements listed below.

a) MICROSCOPE

i. Inverted optical design for maximum accessibility to sample stage
ii. Epi/incident light illumination for optimal Field of View uniformity
iii. Provisions for two views with mounting apparatus for two cameras
iv. Multiple Objectives to cover a range of working Fields of View from ≥ ~ 1.5 mm x 1.5 mm to ≤ ~ 0.15 mm x 0.15 mm
v. Long working distances for objectives (e.g. ≥ ~ 1.5 mm for ~ 63X with NA ≥ ~ 0.75)
vi. Fiber coupling for light input to match light sources
vii. Calibration mask for calibrating at each magnification setting

b) CAMERAS - Two cameras

i. Camera for velocity images optimized for spatial and temporal resolution, cross-correlation (frame straddling) and/or auto-correlation (multiple exposure) data collection
ii. Camera for fluorescence imaging optimized for sensitivity (wavelength response, quantum efficiency, and dynamic range), and spatial and temporal resolution
iii. ≥ 1.4 Megapixels, pixel size ≤ 6.5 μm x 6.5 μm; quantum efficiency: ≥ 60% @ 532 nm, ≥ 50% @ 700 nm, ≥ 10% @ 900 nm, ≥ 3% @ 1000 nm; resolution ≥ 12 bits gray scale
iv. The combined microscope and cameras must provide a range of magnification settings (minimum of four) to provide Fields of View from ~ 100 μm x 100 μm to ~ 1000 μm x 1000 μm
v. The combined microscope and cameras must provide a Depth of Field resolution ≤ 2 μm and a lateral resolution ≤ 0.5 μm at highest magnification
vi. Combined microscope and velocity camera must provide valid velocity vectors with ≤ 2.5 μm vector resolution at the highest magnification
vii. SYSTEM must provide a "physical view" of the sample region from both cameras
viii. SYSTEM transmission and response (including optics, fluorescence imaging camera, and filters) must have a ***realistic*** working range from 350 nm to 900 nm
ix. SYSTEM must provide for multiple wavelength fluorescence imaging capabilities. At a minimum with excitation at 532 nm, the SYSTEM must include a long pass emission filter to discriminate against the 532 nm excitation and record images for emissions ≥ 540 nm with no detection of the excitation light.
x. At a minimum, the SYSTEM must be capable of recording credible fluorescence images for banded emission (width of ~ 20 nm to 30 nm) at wavelengths centered at ~ 550 nm, ~ 590 nm, and at ~ 750 nm.
xi. For "bright" light source (see specs below), SYSTEM must include filter/separation optics to illuminate from ~ 350 nm to ~ 530 nm and collect emission > ~ 530 nm to ~ 900 nm.

c) LIGHT SOURCES AND ASSOCIATED OPTICS
Two light sources must be provided, one to cover velocity monitoring requirements and one for fluorescence imaging at high magnification.

i. Pulsed Laser Source ≥ 50 mJ per pulse dual Nd:YAG lasers fiber coupled output

- ≥ 15 Hz operation
- Beam combining optics
- Optical fiber suitable for laser source to connect laser source to microscope, minimum length 3 meters.
- Fiber couplers (using standard coupling) to connect laser light source to fiber and fiber to microscope.
- Lasers warranty to include minimum of 5000 hours of operation

ii. "Bright" light source

- Metal halide lamp light source capable of delivering continuous and pulsed light

- ≥ 100 Watt output
- Control method for intensity of light delivered to sample region with computer interface
- ≥ 2 meter long light guide with couplings to "bright" light source and microscope
- Optics to provide uniform Field of View illumination
- ≥ 1000 hours lamp lifetime
- One additional "replacement" lamp

d) 3-D MOTORIZED IMAGE STAGE

i. The sample image stage must have both manual and computer positioning control (motorized 3-D movement) with fine and coarse movement in all three dimensions.
ii. Load capacity: ≥ 2 kg for horizontal movement, ≥ 7 kg vertical movement
iii. Stage position reproducibility must be ≤ ± 0.2 micrometers.
iv. 3-D control of the image stage (computer and manual) must be able to manipulate the stage over a distance ≥ 100 mm in-plane (both x and y) and ≥ 20 mm out-of-plane (z).
v. Stage movement control must include limit switches (hardware or software) or suitable preventive protocol to limit stage movement past critical positions (as defined by the specific experiment).

e) PROCESSOR/COMPUTER

i. Minimum requirements: processor speed and functionality equivalent to or better than two dual core Xeon, ≥ 4 GB memory, two hard disks each ≥ 250 GB, network ready.

ii. Flat panel monitor (≥ 21 inch), and high speed Read/Write CD and DVD units for data transfer.
iii. Hardware interface including timing modules and all cables for connecting and controlling light sources, stage, and cameras

f) SOFTWARE

i. Software control for light source, stage positioning, camera operation, and synchronization electronics
ii. Software for straightforward field-of-view calibration; calibration settings integrated into image collection and reduction software.
iii. Software for image capture, analysis, storage, display (raw and processed data), and retrieval
iv. Software for deriving and displaying velocity vectors (and derived information including vorticity, gradients, stream lines, and statistical parameters)
v. Software for deriving and displaying fluorescence image-derived quantities (including concentration, temperature, and pH) and typical derived information including gradients and statistical parameters.
vi. Software for sizing of particles/bubbles/voids/structures based on images
vii. Software and hardware to provide timing synchronization with external events, time stamping (hardware inputs with software interrupts and/or software generated output sync triggers), and timed data collection.
viii. Software for advanced image processing (including smoothing, pixel correction, image subtraction, non-linear alterations, etc.)

2) The SYSTEM must be able to determine flow velocities in the imaged region ≥ 2 m/sec as well as flows with near zero velocity. The SYSTEM must be able to determine flow direction information in the imaged region over this velocity range.

3) The SYSTEM procurement shall include a minimum of two sizes of "flow seeder" fluorescing seed particles: ≥ 40 g particles in water solution of nominal ≤ 10 micrometer diameter particles, and ≥ 40 g particles in water solution of nominal ≤ 1 micrometer diameter particles.

4) The SYSTEM price must include installation, testing, and demonstration on a microfluidic device of the Vendor's choosing to show maximum system performance and on an NRL furnished micro-fluidic device to demonstrate flexibility of design. Both flow velocity and fluorescence imaging acquisition must be demonstrated in real time.

5) Demonstration of the SYSTEM including verified calibration, testing are to be performed on site at NRL on the delivered SYSTEM.

6) Testing and calibration documentation, as well as complete instrument documentation manuals (detailing at a minimum the hardware and data acquisition, processing, data presentation and storage) must be provided at the time of installation.

7) During testing on site, the SYSTEM must satisfactorily perform in the measurement of flows in a microfluidic channel at a minimum for flows of ~ 2/cm/s and ~ 200 cm/s for a water only flow and for water mixing with alcohol. Testing must demonstrate data collection, data processing, display of processed data, data storage and retrieval including velocity profiles, fluorescence images, statistics, S/N analysis, and raw images.

8) Before CONTRACTOR leaves site during testing (Item 8), the complete SYSTEM including lasers, processors, motorized stage, etc., must operate continuously for a minimum of 5 (five) hours with no malfunctions.