Construction of Synthetic Gel Metrics

CNF Project # 398-91

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Abstract:

Ecology and Evolution Dynamics via Micro-Ecologies. This effort will act as a laboratory for the study of the evolution and adaptation of organisms under highly controlled conditions of stress. The output of these micro-ecologies can be analyzed and studied by the ideas that we have developed in the nanotechnologies leading up to this latest effort.

Summary of Research:

We are designing micro-ecologies and analyzing how and why the cells change under stress. The most significant 2008 paper in this area was “Computation of mutual fitness by competing bacteria” [1], which showed how competing bacteria optimize fitness through self-organized spatial segregation. We have also been playing with how cells interact with the microfabricated structure. Our most significant paper from 2008 was “Funnel ratchets in biology at low Reynolds number: choanotaxis” [2]. The cell contents of these evolution experiments can be probed by technologies we are developing: Single molecule correlation spectroscopy in continuous flow mixers with zero-mode waveguides [3], hydrodynamic metamaterials to cross microfluidic streamlines [4], and deterministic microfluidic ratchets [5].

References:


Figure 1: Schematic of a 2-level nutrient landscape device. Wild type bacteria (labeled with green fluorescent proteins) and rpoS819 stress mutants (labeled with red fluorescent proteins) are free to move within the Micro Habitat patches (MHPs) and may migrate from one region to the other. The nutrient reservoir is coupled to the MHP by nanoslits.
Figure 2: (a) and (b) A zero-mode waveguide method confines intensity fluctuation measurements to diffusers proximate to the metal substrate within the zero-mode waveguide. (c) and (d) Scanning electron microscope image of a zero-mode wave guide. Scale: $h = 163$ nm, $R = 209$ nm and $r = 26$ nm.

Figure 3: (A) Prismatic metamaterial element is formed by joining an $+\alpha$ array (upstream) to a $-\alpha$ array (downstream). (B) SEM top view of the sub-element boundary. Element dimensions: 11 $\mu$m pitch, 3.7 $\mu$m gap and 18 $\mu$m deep etch. (C) and (D) $-\alpha$ array tiled above a $+\alpha$ array forms a focusing metamaterial element, $+F$. Here, supercritical 3.0 $\mu$m particles enter the microfluidic device from a single inlet port and are focused into a hydrodynamic jet.

Figure 4: (A) Micrograph of triangular post array. The right isosceles triangles are 6 $\mu$m on a side with post to post separation of 10 $\mu$m and tilt angle of 5.7° with respect to the horizontal fluid flow. Fluid flow was forced to be horizontal by confining walls on the top and bottom of the device. (B) Images of the trajectories of 1.1 $\mu$m spherical polystyrene beads as the direction of fluid flow is cycled back and forth twice, (C) 3.1 $\mu$m, and (D) 1.9 $\mu$m. Particles in (B) and (C) retrace their paths when the direction of the fluid is switched while the trajectory in (D) varies with the direction of the fluid flow.