Supplementary Information

Real-Time Pressure Monitoring System in Microfluidic Devices by Deformable Colloidal Crystal Membrane

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S1. Angle dependent reflectance of colloidal crystal membrane.

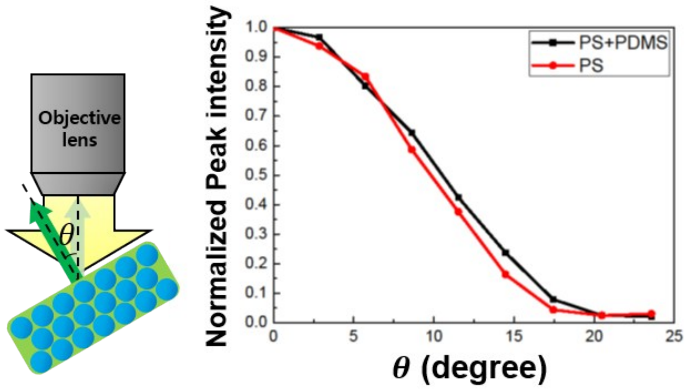

Fig. S1 Angle dependent reflectance peak intensity of bare PS colloidal crystal (red) and PS-PDMS composite (black). By changing the angle of sample on microscope, incident and observing angle of light are varied.

S2. Islands of colloidal crystal grains and membrane expansion

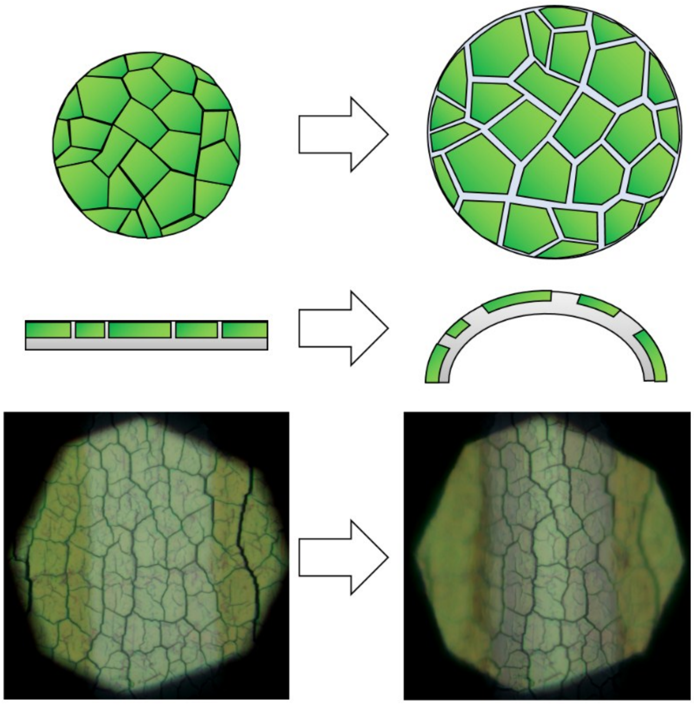

Fig. S2 Scheme (top) and optical microscopy images (bottom) of colloidal crystal membrane before (left) and after (right) the membrane expansion.

S3. Computational analysis of membrane deformation

For computation analysis, COMSOL Multiphysics® Modeling Software was used. To simulate the pressure caused by the flow and the resulting membrane deformation, fluid-structure interaction (FSI) physics and moving mesh were used. We set up the geometry of microchannel with membrane and simulate with various flow rate and loaded pressure. After confirming the pressure distribution and membrane deformation due to the flow and loaded pressure, a disk with radius of 300 μm was set up in solid mechanic physics to be deformable to center radius of 150 μm. When pressure was loaded to the center, the deformable disk was simulated according to the various thickness and physical properties. Simulation result meshes were remeshed with deformed configuration and exported to raw data file to use in ray-tracing simulation. Subsequently, geometrical optic physics in COMSOL was used to simulate ray-tracing. We set up geometry as Fig. 3 (a) to count reflected ray. 10,000 rays were introduced upward and became parallel light of intended area. The rays were going through lens, focused to deformed sample and reflected from sample surface. Sample was imported mesh that result of pressure driven deformed disk. Reflected rays were counted with 2D plot of data set intersection point 3D located under lens.

S4. Ray tracing simulation results

The representative simulation data in Fig. S4 show that omnidirectional light scattering occurs when the membrane deformation is small. Notably, there was no difference in the number of reflected rays (i.e. reflectance) for the membranes with different thickness and elastic modulus as long as the deformed height was the same (Fig. S5)

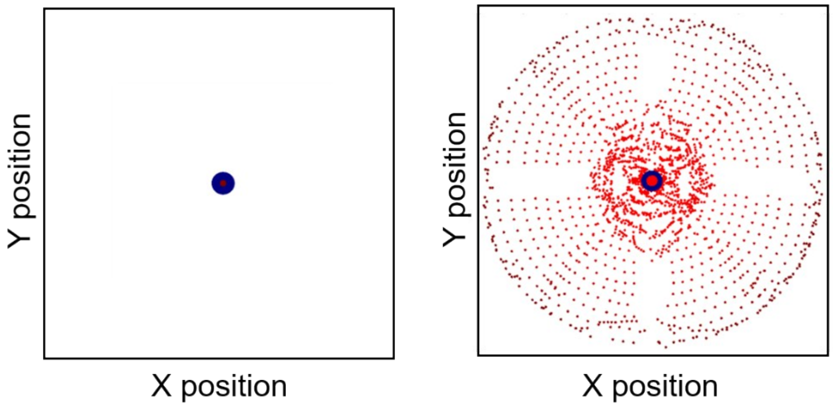

Fig. S3 Ray tracing simulation results for reflection of 10,000 rays of light by flat (left) and curved (right) bottom. Rays introduced from light source (blue) and reflected from the sample (red) were plotted simultaneously.

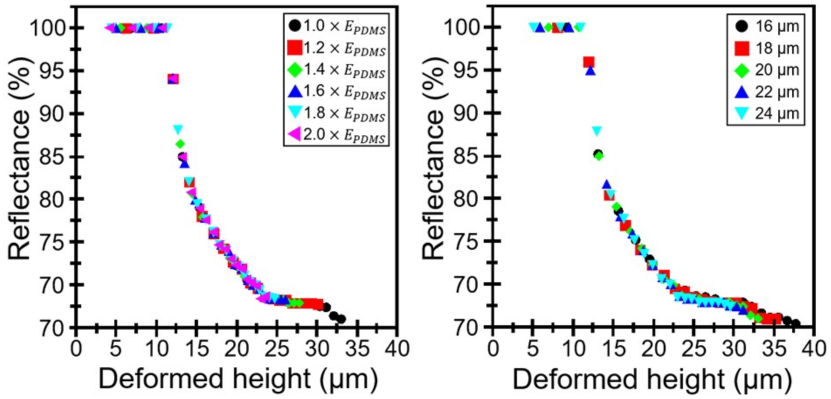

Fig. S4 Deformed height-reflectance graph obtained by ray-tracing simulation. Reflectance changes were calculated by varying the elastic modulus (left) and thickness (right) of membrane.

S5. Computational results for membrane profile and membrane angle by pressure

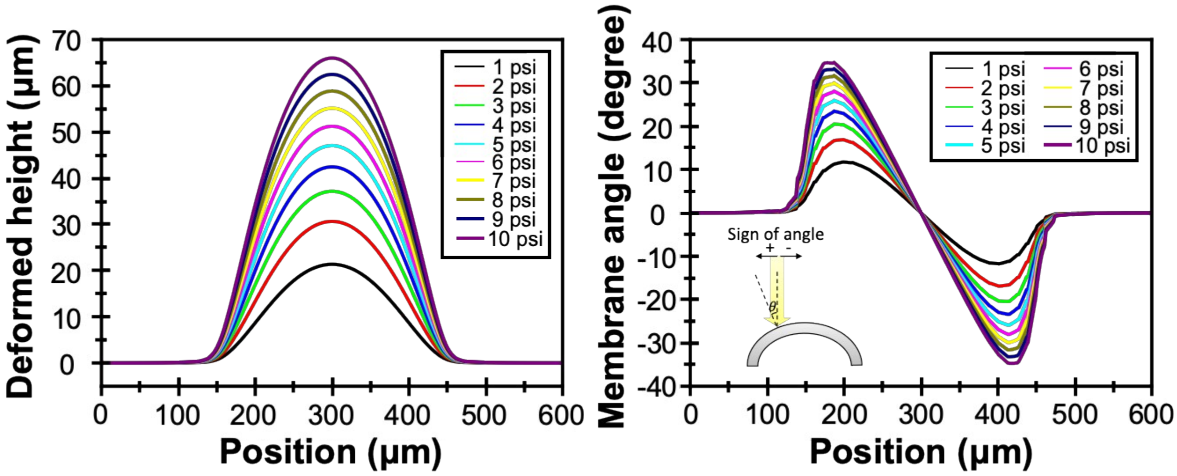

Fig. S5 Computational results for membrane profile (left) and membrane angle, θ, with incident light (right) at various pressure.

S6. Dynamic pressure monitoring after turning off the syringe pump

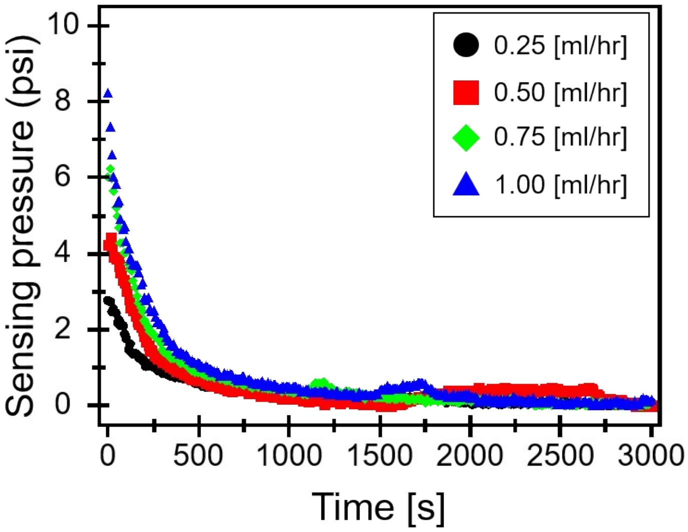

Fig. S6 Dynamic pressure monitoring after turning off the syringe pump. Equilibrium flow rate before turning off the pump were varied from 0.25 (black), 0.50 (red), 0.75 (green), and 1.00 ml h^{-1} (blue).