Supplementary Information

Fabrication of the nanochannels began with casting degassed PDMS prepolymer (Dow Sylgard 184, 10:1 polymer to curing agent) against a photolithographically-prepared SU-8 (Epoxy-based photoresist, MicroChem) mold containing the positive pattern of two microchannels (width = 100 μm, height = 50 μm). The microchannels were parallel and spaced 1 mm apart over a length of 6.75 mm; they angled away from one another at 30° on either end over a distance of 3.125 mm (Fig. 1A). The PDMS was cured at 60°C for 12-15 hours. After curing, the PDMS was removed from the mold, and a slab of PDMS (8.5 mm wide by 40 mm long) was cut to contain the pair of microchannel reservoirs (Fig. 1a). Inlet and outlet ports were created at either end of the two microchannel reservoirs using a 1.5 mm-outer diameter biopsy punch. This substrate was then placed, patterned side exposed, on a glass slide covered by paper tape so that it could be transported without being deformed.

Featureless films about 160 μm thick were made from the same PDMS for use as the second, mating substrate. These films were created by depositing the prepolymer onto silane-treated glass slides, and using a spin coater (Brewer Science, Cee 100) to evenly coat the slides. The PDMS-coated glass slides were cured in a 60°C oven for 12-15 hours. The thin film remained attached to a glass slide until bonding with the slab.

Both the microchannel-patterned slab and the spin-coated film were cleaned using Scotch® tape. They were then placed in a vacuum (40-60 mTorr) for 10-20 minutes prior to exposure to plasma oxygen for 60 minutes (Harrick Plasma, 30 W). Immediately after the plasma treatment, the exposed surfaces of the substrates were placed in contact with one another, which led to spontaneous permanent bonding. Finally, the device was detached from the glass slide that had been used for spin coating the featureless film. This had to be done carefully, to avoid introducing unwanted cracks within the brittle layer at this stage. The PDMS/glass edges were briefly soaked with ethanol while sliding the tip of a scalpel blade in between the glass and the PDMS film to release the bonded system without bending or twisting it.

The bonded system was loaded into a stretcher (Micro-Vice Holder; S.T. Japan, USA LLC, Ft. Myers, FL), and a uniaxial tensile strain was applied to introduce the

nanochannels. The stretcher was fitted with a custom-built *x-y* stage for an epi-fluorescence microscope (Nikon TE-300); this allowed *in-situ* optical observations of the formation of the tunnel cracks during straining in phase-contrast, transmitted-light mode. A 60x oil-immersion objective (Nikon Plan Apochromat, NA=1.40) was used to view individual nanochannels and their contents and a 20x objective (Nikon Plan Fluorite, NA=0.45) was used to view series of nanochannels. Images were captured using a CCD camera (Hamamatsu ORCA-ER).

An additional preparation step was required to achieve wetting of the nanochannels before using them for fluidic applications. Two different procedures were explored to enhance the wetting of the nanochannels. In one procedure, the nanochannels were further treated with plasma oxygen to render their surfaces hydrophilic. This was achieved by immediately loading a bonded device into a custom-built screw-driven slider and rail stretching system and applying a strain to generate the required density of nanochannels (between 15 and 20% in the present set of experiments) while exposing the system to plasma oxygen at 30 W for an additional 30 minutes. In the second procedure, the solution of interest was introduced into both microchannels, and several cycles of straining and relaxing between zero strain and the maximum strain at which the device was to be used (approximately 25-30%) were applied. This created a pumping action that coaxed the solution into the nanochannels. Once the nanochannels were wetted, they remained functional for the performance of the desired experiments.