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Eletrokinetic Protein Preconcentration Using Nanochannels Formed By Weak Bonding of PDMS Membrane with Glass Substrate

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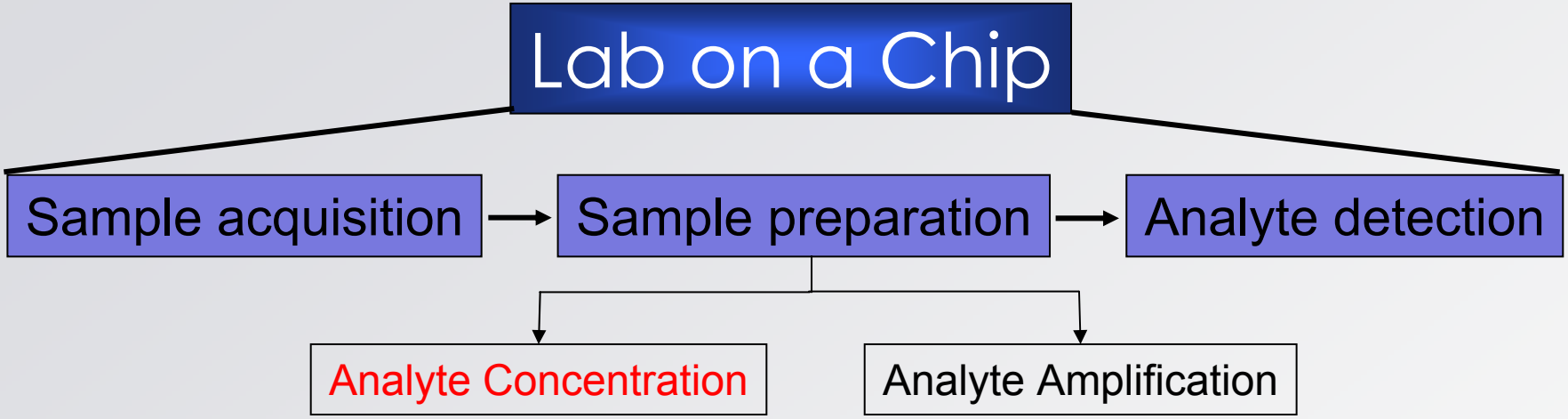
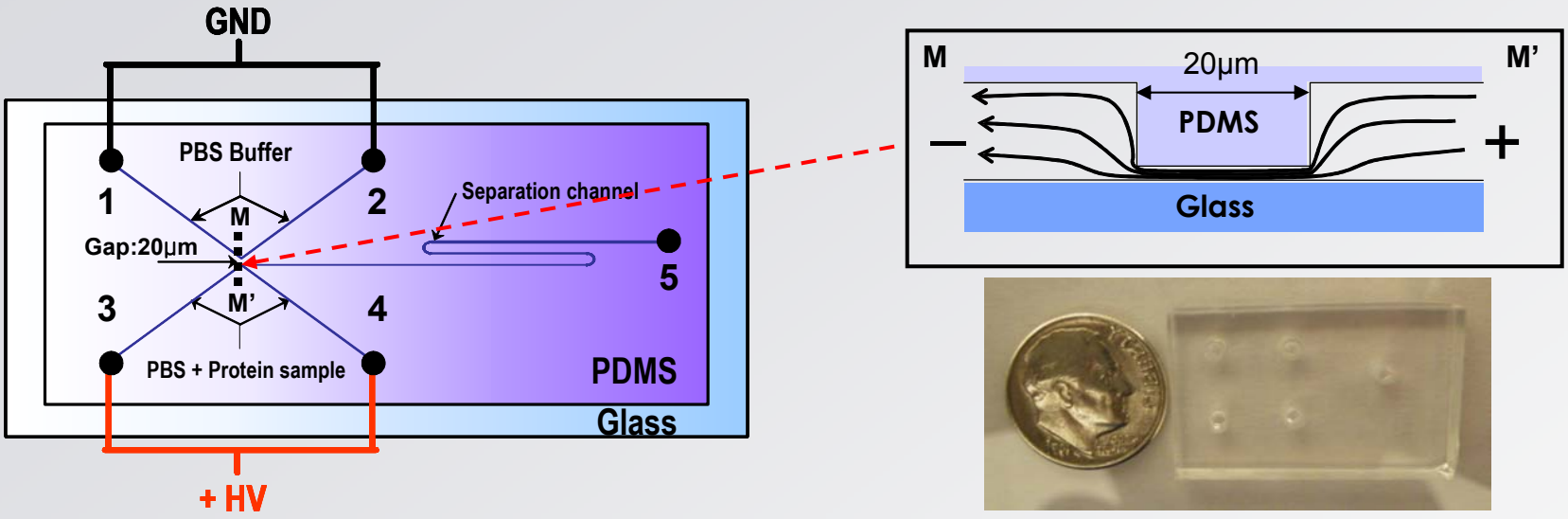
Lab on a chip (Laboratory on a chip)



Why concentrate samples?

- **Sensitivity**: Concentration in sample often less than detection limits of instruments
- **Waste**: Most samples are > 1 mL in size, but only nanoliters can be analyzed at a time on a microchip

Simple Glass/PDMS Preconcentrator



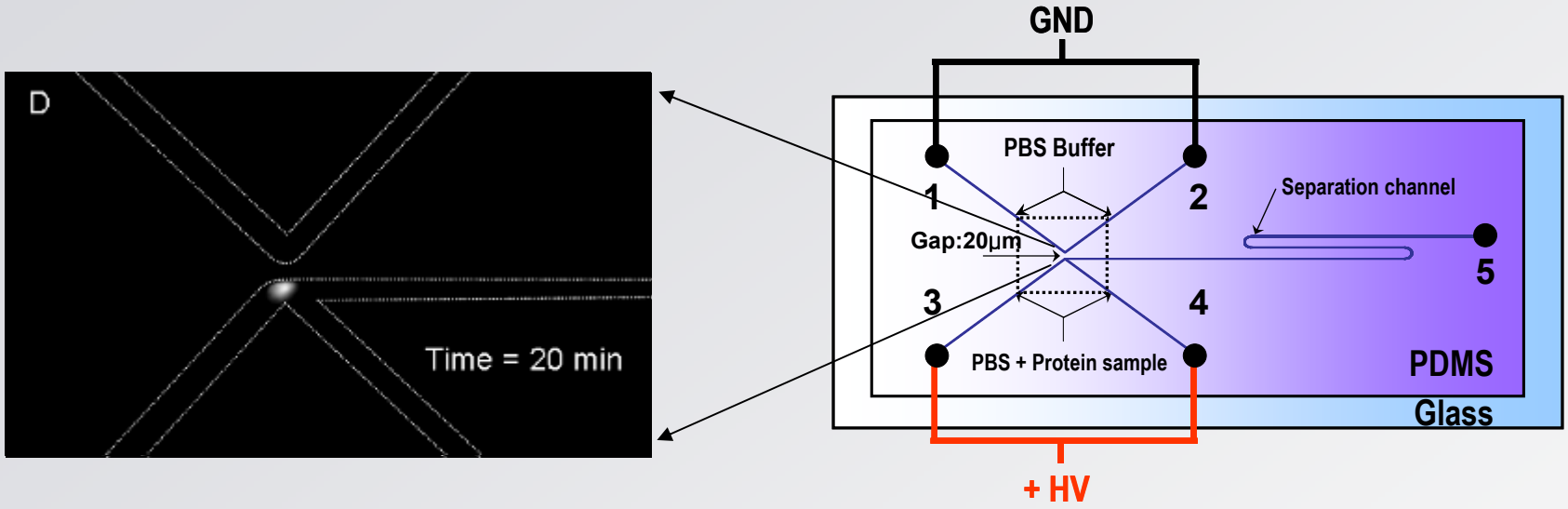
- Channel dimensions

  Chevron channels (W 40μm× D 18μm, L=16mm),

  Separation channel (W 30μm× D 18μm, L=40mm)

- Microchannels are created by casting PDMS over a mold (SU-8 on a Si substrate).

Experimental Results

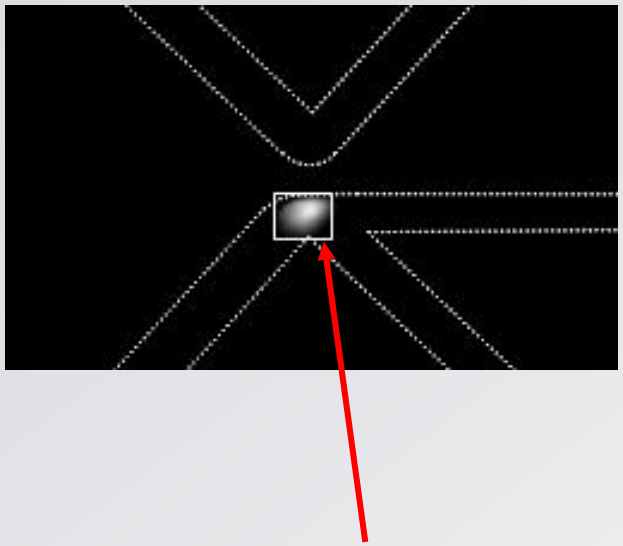


Experimental conditions

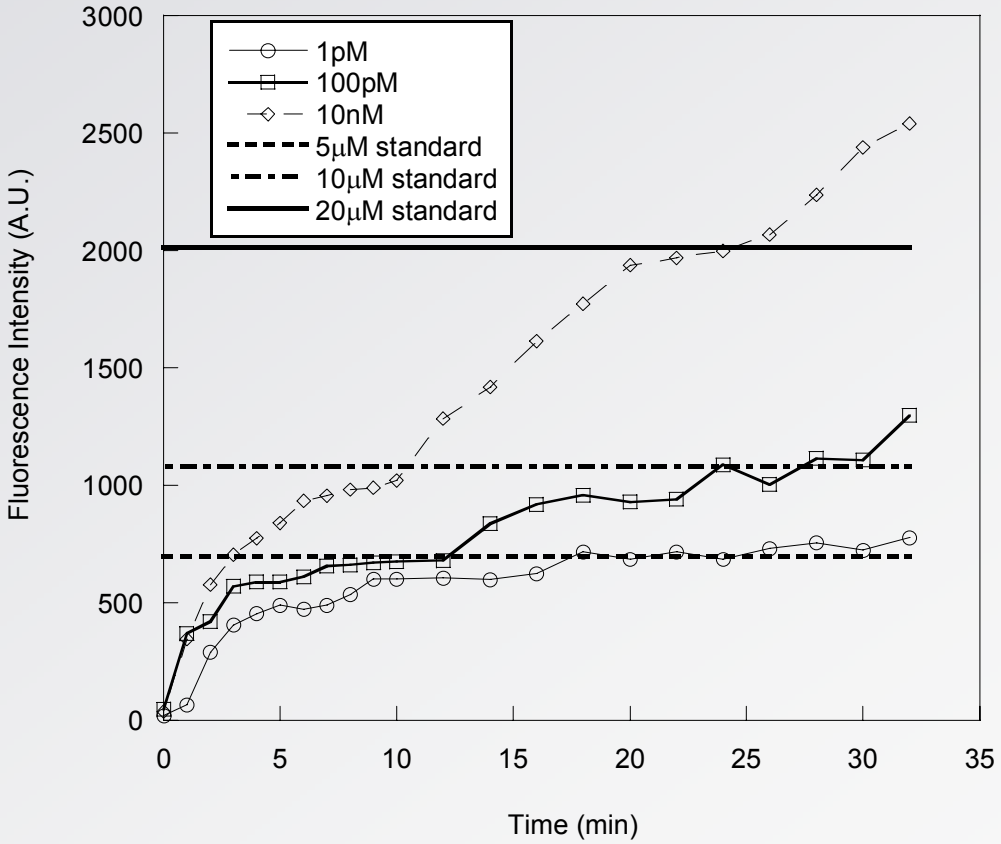
- Protein sample : Fluorescein isothiocyanate (FITC) conjugate bovine serum albumin (BSA) and ovalbumin (OVA)
- Buffer : Phosphate-buffered saline buffer (10mM, pH 7.4) and Phosphate buffer (20mM, pH 7.2)
- O_2 plasma treatment of the PDMS (100W, 200mTorr, 3min)
- Applied electric potential: 100, 200, 300V

Experimental Results (cont'd)

Concentration of FITC-BSA in the preconcentration zone

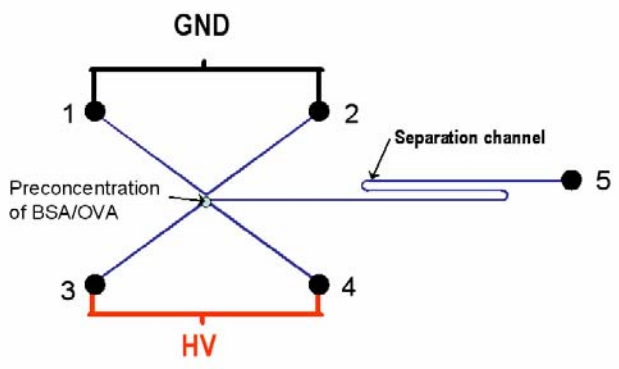


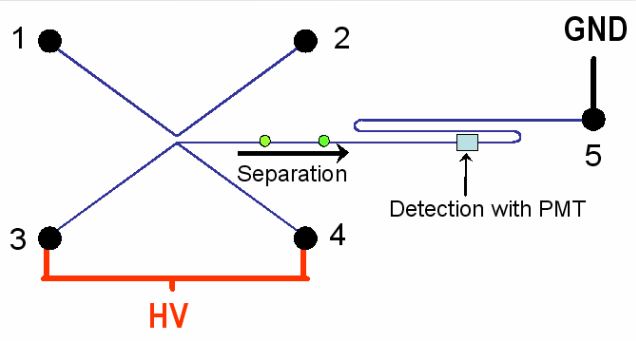
Preconcentration Zone

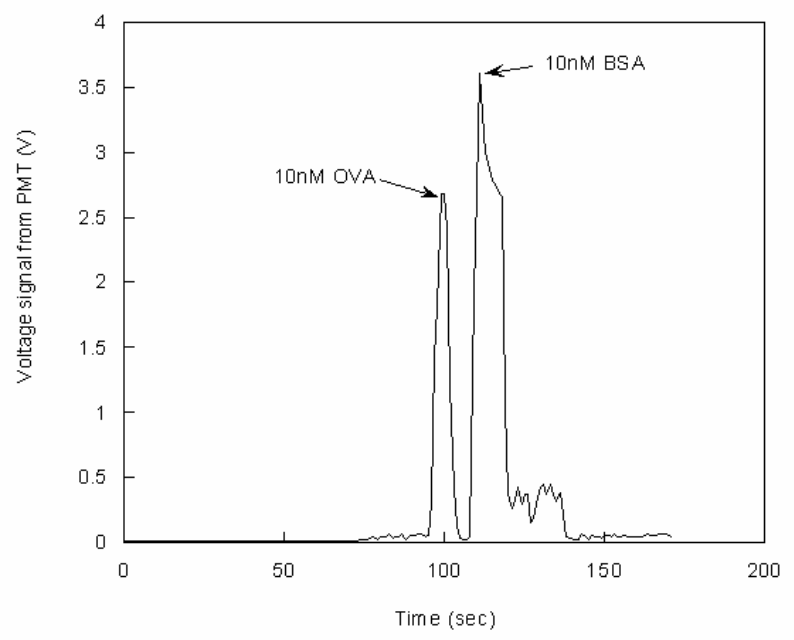


➡ Concentration achieved up to 10^6 –fold

Separation of preconcentrated proteins



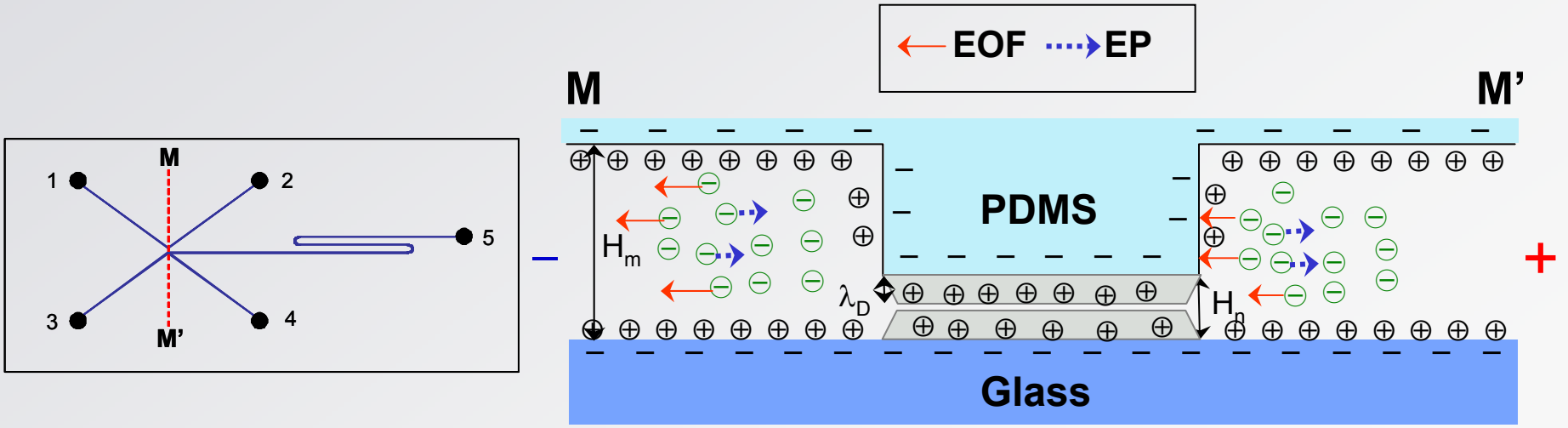




Physical Mechanism: Hypothesis and Verifications

"*nanoscale channels*" formed between the PDMS and the glass due to the weak, reversible bonding

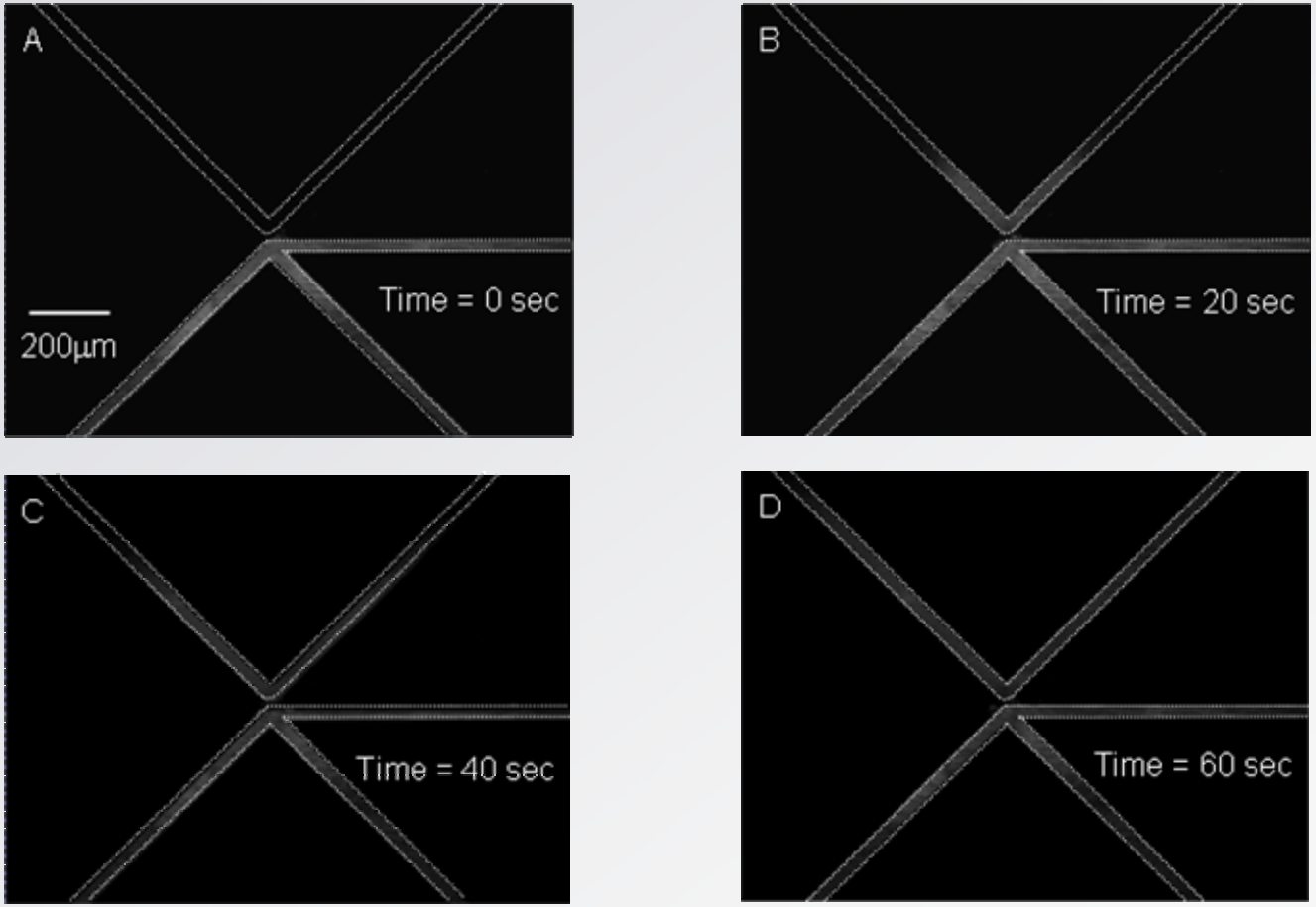
1. No preconcentration occurs in PDMS/PDMS and *ir*reversibly bonded PDMS/glass (stronger bond) chips.
2. Nanochannels work as a ***cationic selective membrane*** due to the Ion exclusion-enrichment effect (EEE) caused by electrical double layer (EDL) overlapping.
3. Electroosmotic flow (EOF) dominates over electrophoresis (EP)



Experimental Verifications

Verification of the cationic selectivity of the nanochannel

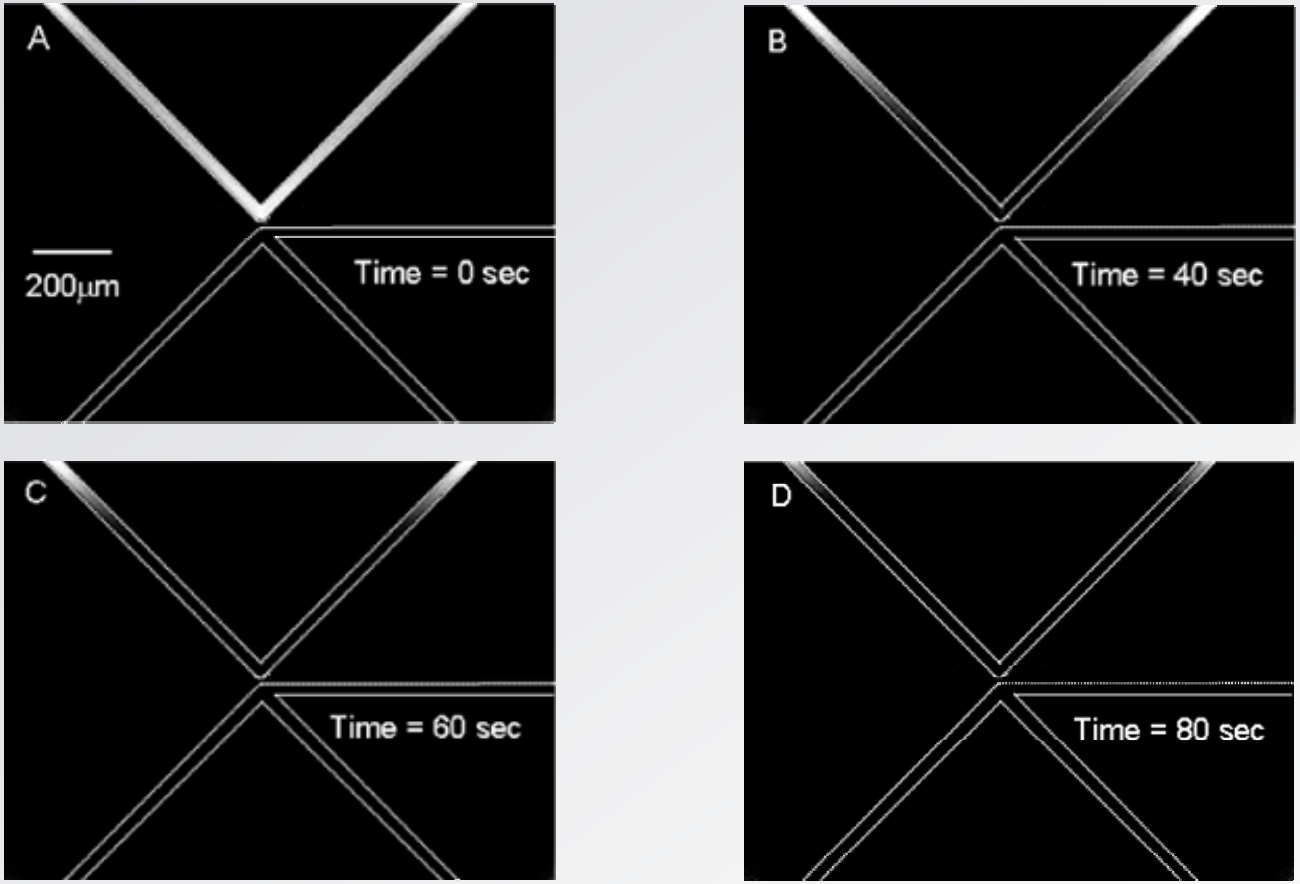
– Sample: 1μM Rhodamine 123 dye (cationic) in PBS buffer (bottom)



Experimental Verifications (cont'd)

Verification of the dominant electroosmotic flow (EOF)

– Sample: 1μM FITC-BSA in PBS buffer (Top)



Conclusions

- PDMS / Glass chip for protein preconcentration was designed and fabricated.
- Preconcentration of labeled BSA (FITC BSA) has been achieved up to 10^6 – fold.
- Preconcentrated protein was injected and separated in a separation column.
- "Nanoscale channels" formed between the PDMS and the glass due to the weak, reversible bonding works as a cationic selectivity membrane by Ion exclusion-enrichment effect (EEE).