Intelligent Front-end Sample Preparation Tool using Acoustic Streaming

Sandia National Laboratories

Darren W. Branch, Steve Casalnuovo, Erika J. Cooley, Gennifer Smith, Thayne L. Edwards, Conrad D. James, Komandoor Achyuthan, Jamie McClain, Jaclyn Murton, John M. Anderson, Joe Kotulski, Paul G. Clem

Problem

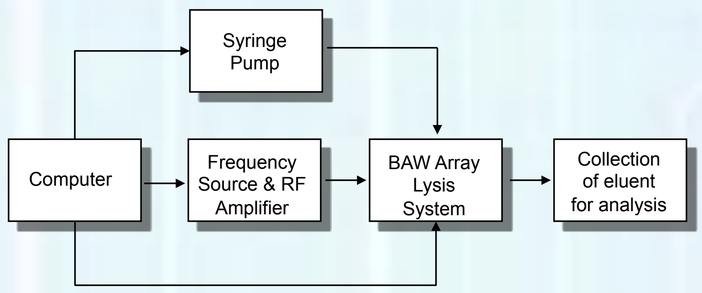
- Sample preparation is the rate-limiting step in nearly all biodetection systems, due to the laborious and time-consuming processing required prior to sample analysis.
- The development of rapid, high-throughput separation methods for DNA extraction and analysis in a single device is required to improve analysis times and the characterization of complex samples.

Project Goals:

- To develop technology that enables cell lysis within tens of seconds, permits lossless DNA extraction (while avoiding harsh chemical treatments and interfering agents), and can be coupled to automated DNA detection systems (e.g. PCR).
- Serve as core technology for an NIH proposal by providing crucial species identification and antibiotic susceptibility profiles from clinical samples within two hours.

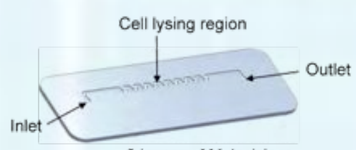
Approach

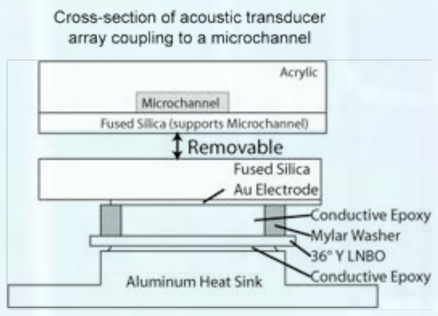
- multidisciplinary effort as it combined areas ranging from physical acoustics to molecular biology.
- Use bulk acoustic waves (BAWs) to disrupt bacterial cell membranes in a microchannel format to release intracellular components and extract DNA.



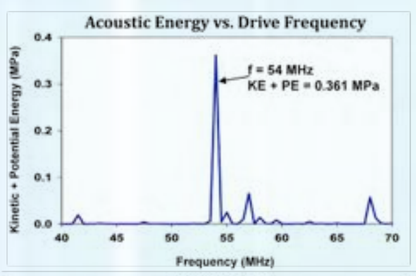
Results

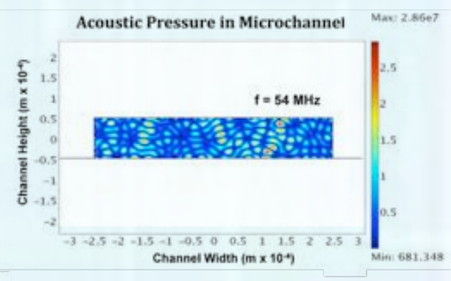
Bulk Acoustic Wave Microfluidic Lysing System

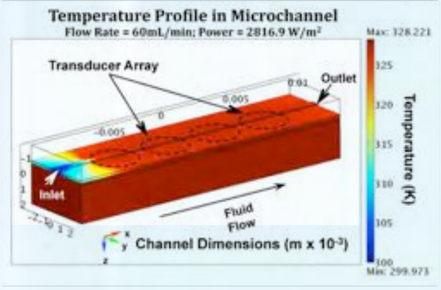


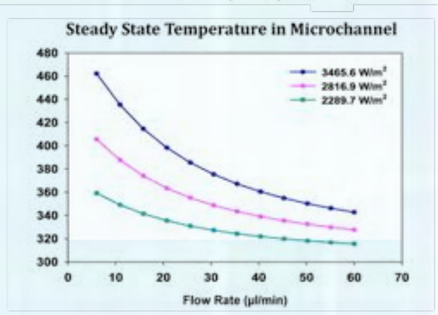


Computer Models





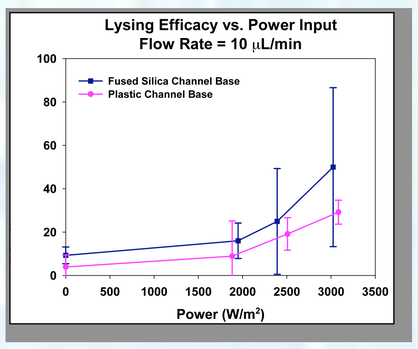


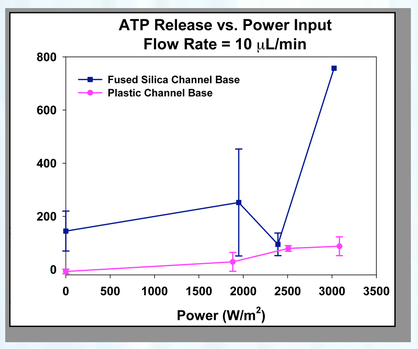


Results (cont.)

BAW Lysing Efficiency

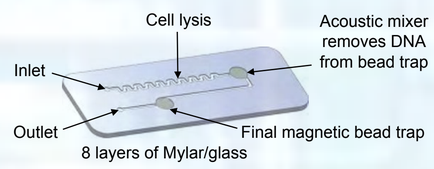
Efficacy of lysing E. coli (K12) cells was assessed by comparing viable cell counts and liberated ATP before and after treatment

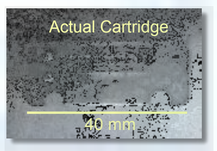




In addition, DNA liberated from lysed samples was quantified and found to be at a concentration of 200 ng/mL

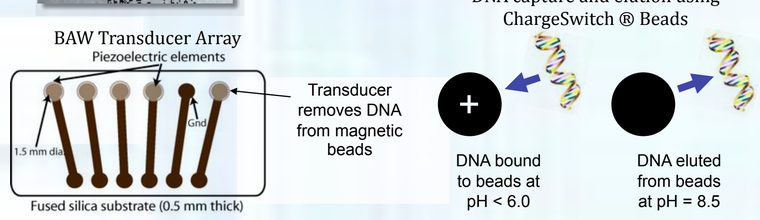
BAW Lysing Efficiency



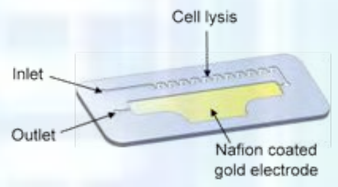


This channel incorporates cell lysis with DNA capture using 1 mm ChargeSwitch® magnetic beads (Invitrogen)

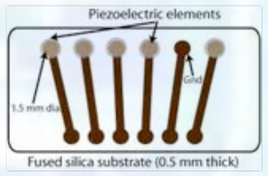
- Quantity of beads loaded into channel ~ $1x10^8$
- < 2% of beads lost during loading into channel
- Binding capacity = 50 ng DNA



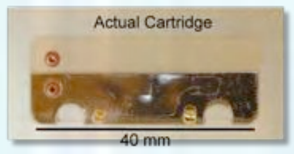
Microfluidic Electrode-Based DNA Extraction



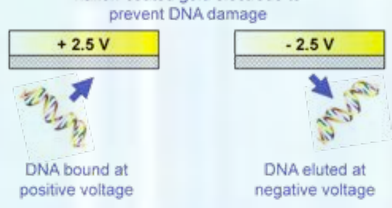
Electrode surface area available for DNA binding: 141.02 mm^2



This cartridge incorporates cell lysis with DNA capture using a Nafion-coated gold electrode



DNA capture and elution using nafion-coated gold electrode to prevent DNA damage

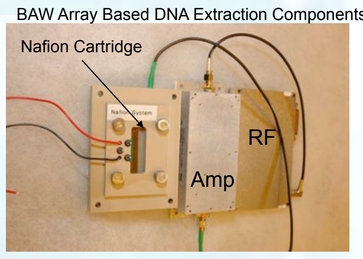


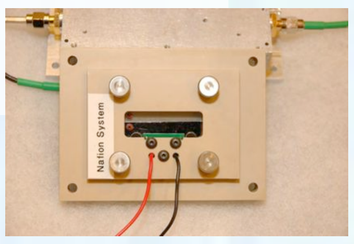
Lee et al., Anal. Biochem. 2008

Significance

- Successfully fabricated bulk acoustic wave transducer arrays at frequencies required to disrupt bacterial cell membranes.
- Demonstrated the ability to lyse *E. coli* in disposable plastic microchannels with fused silica or plastic interfaces to the transducer.
- Developed two DNA extraction cartridges: 1) based on DNA binding magnetic beads and 2) Nafion coated electrodes to reversibly bind DNA, post-lysis.

BAW Array Based DNA Extraction Components





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