



FEA Investigation of Microfabricated Structural Variation in Acoustofluidic Devices



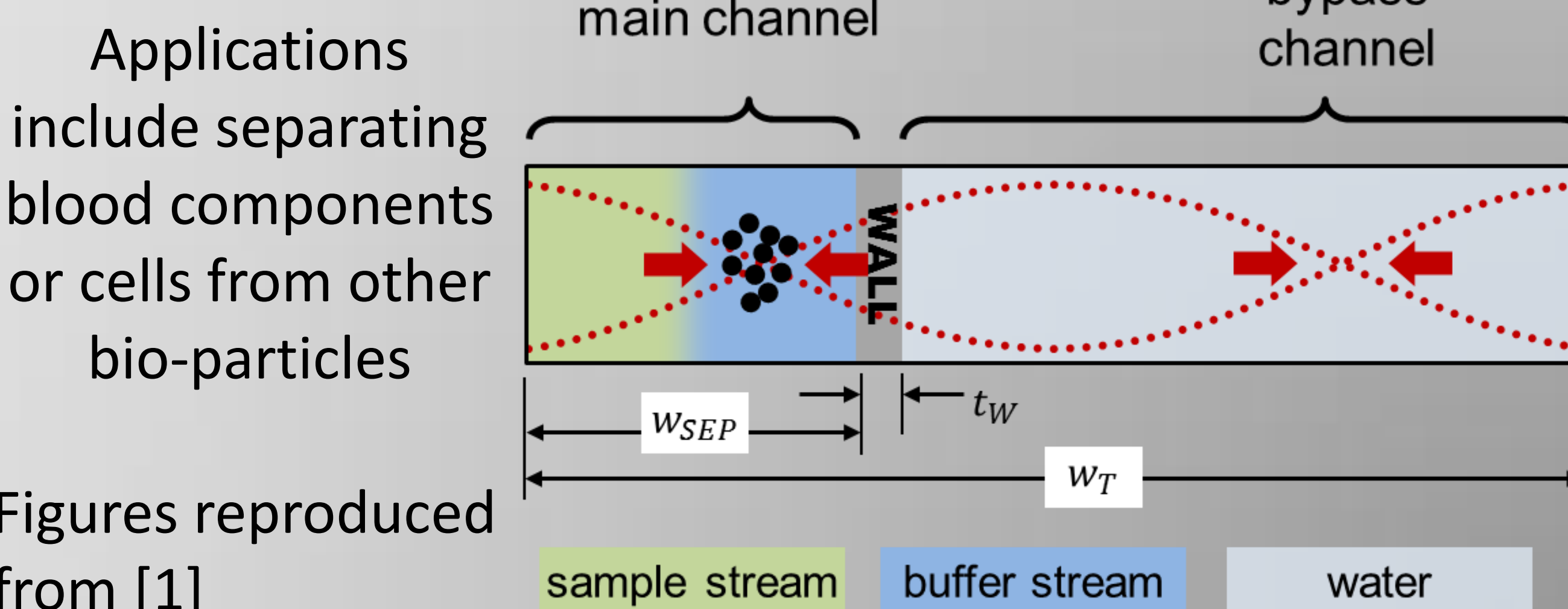
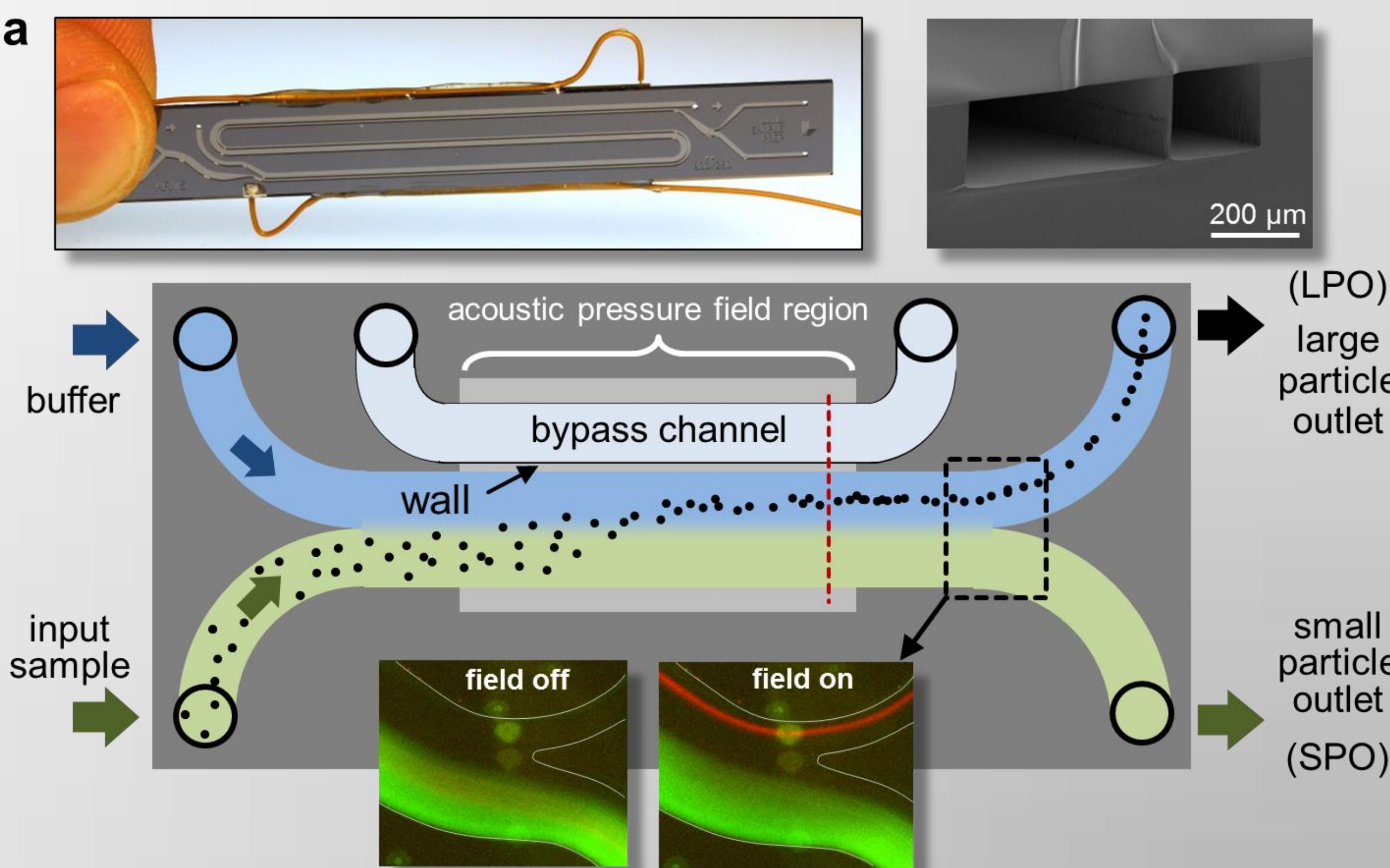
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Microfluidic chips are used to separate particles of differing sizes. A piezoelectric transducer is attached to the silicon chip and produces an ultrasonic standing wave in the channel of the chip. The overall width of the chip is 900 μm and has a thin wall 300 μm from one side. As a sample passes through the chip, the larger particles are concentrated at the low pressure node of the standing wave while the smaller particles are not affected by the wave. The stream of large particles is directed into a separate output than the rest of the sample. When the chips are fabricated, there are small variations in the dimensions of the wall. This leads to each chip acting slightly differently in laboratory tests. The goal of these simulations is to determine the effect of the wall shape and dimensions on the focusing frequency and position. Two dimensional simulations were done in COMSOL Multiphysics using four different wall shapes over a range of 10 μm around the actual dimensions of 13 μm and 6 μm measured from a sample chip. The wall dimensions are taken as the lengths of the top and bottom of the wall. The shape of the wall does not affect focusing frequency. As the difference in the wall dimensions increases, focusing frequency increases and focusing position moves farther from the wall.

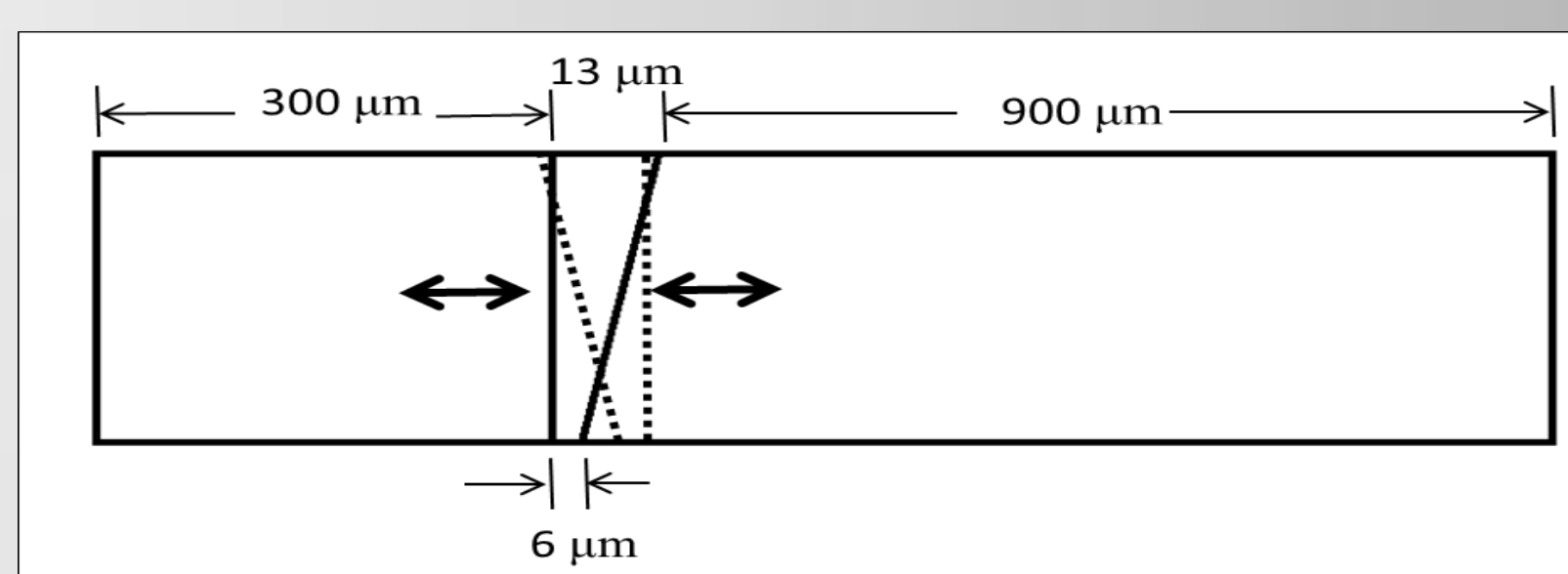
Background

- Silicon chip with etched microfluidic channels
- Coupled piezoelectric transducer produces an ultrasonic standing wave
- Acoustic radiation force size-separates particles: larger particles move toward low pressure nodes

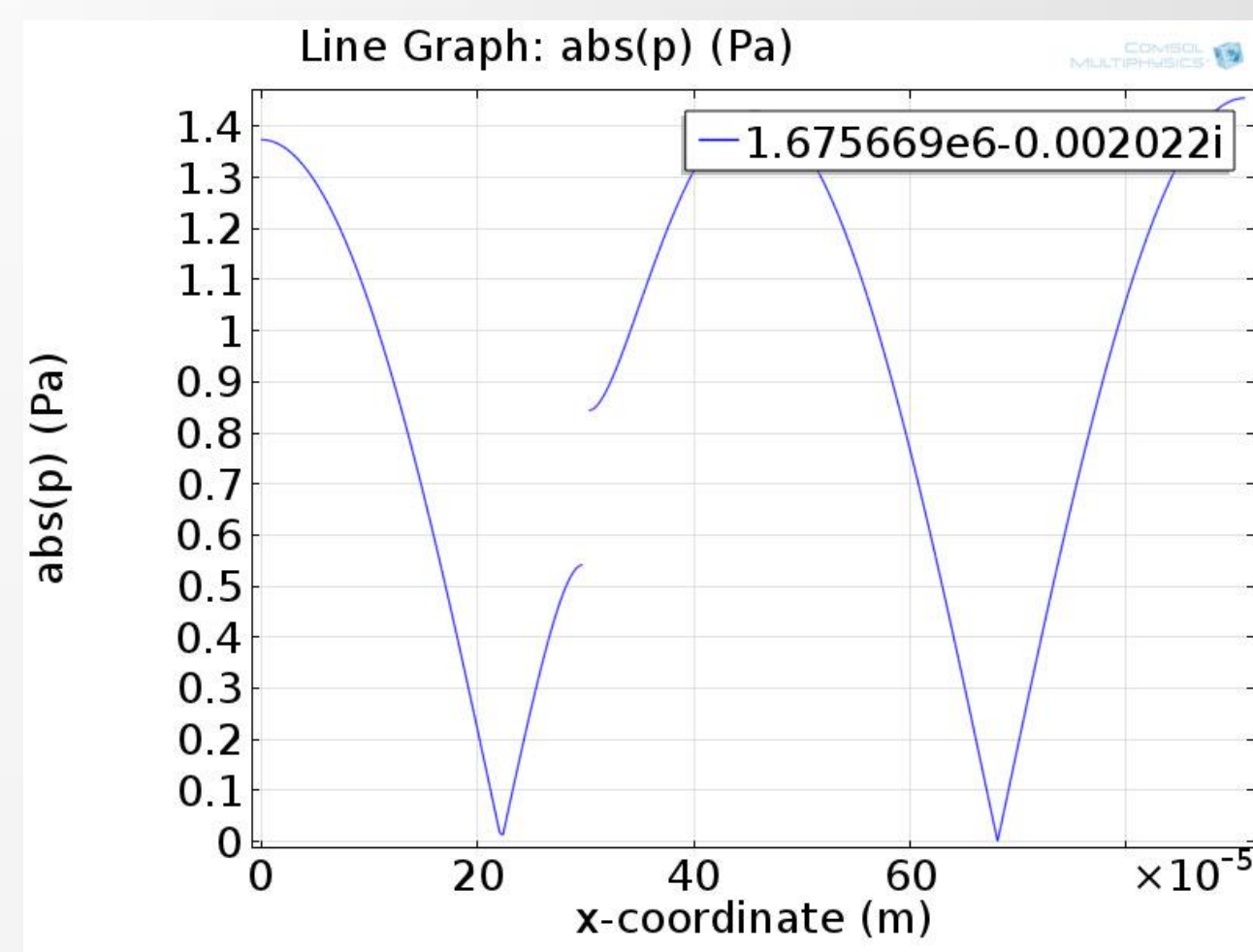


Motivation

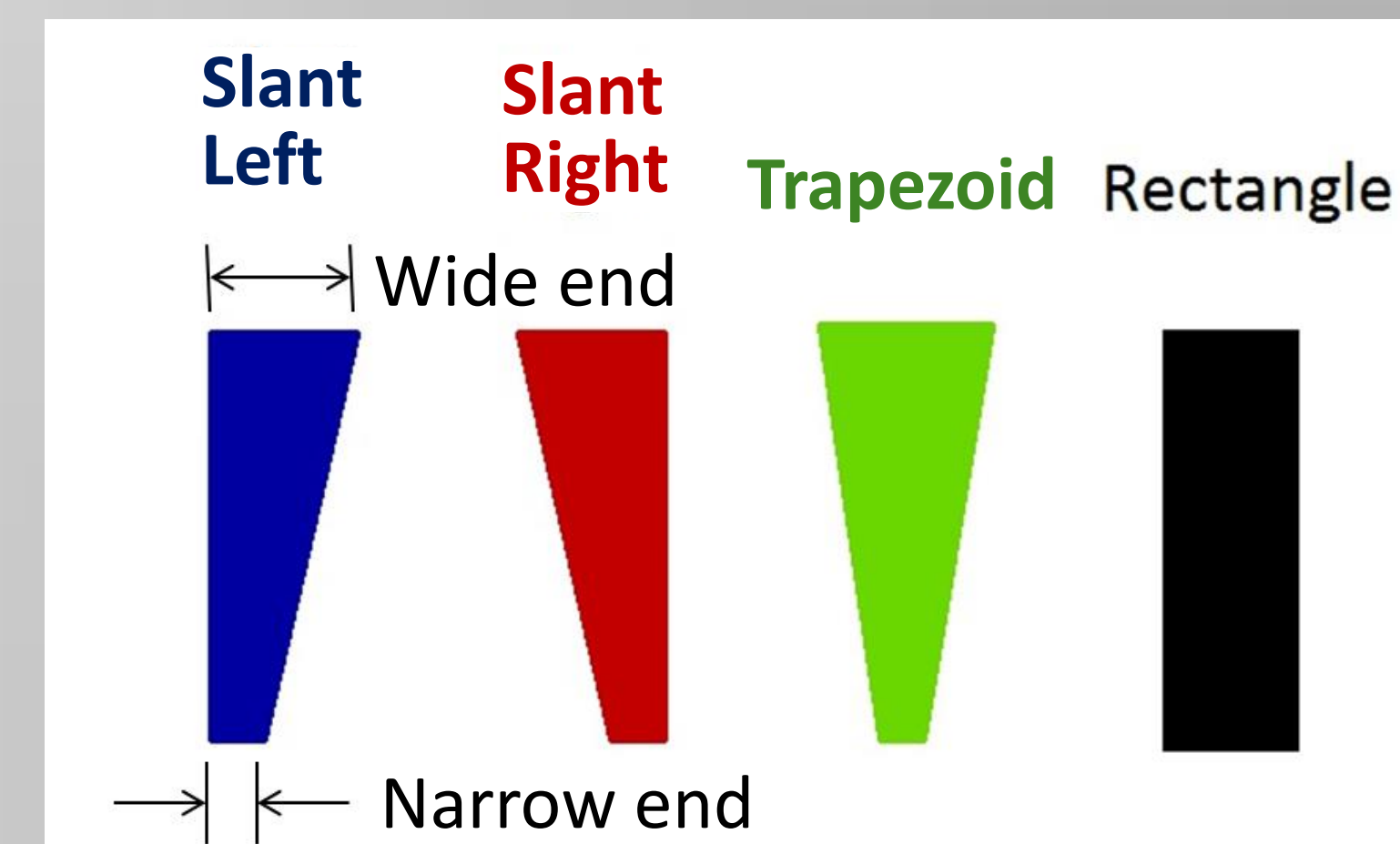
- Experimentally observed variation in focusing performance (location, frequency)
- How much can be attributed to dimensional variations resulting from microfabrication?
- Simulations used to study the effects of changes



Methods

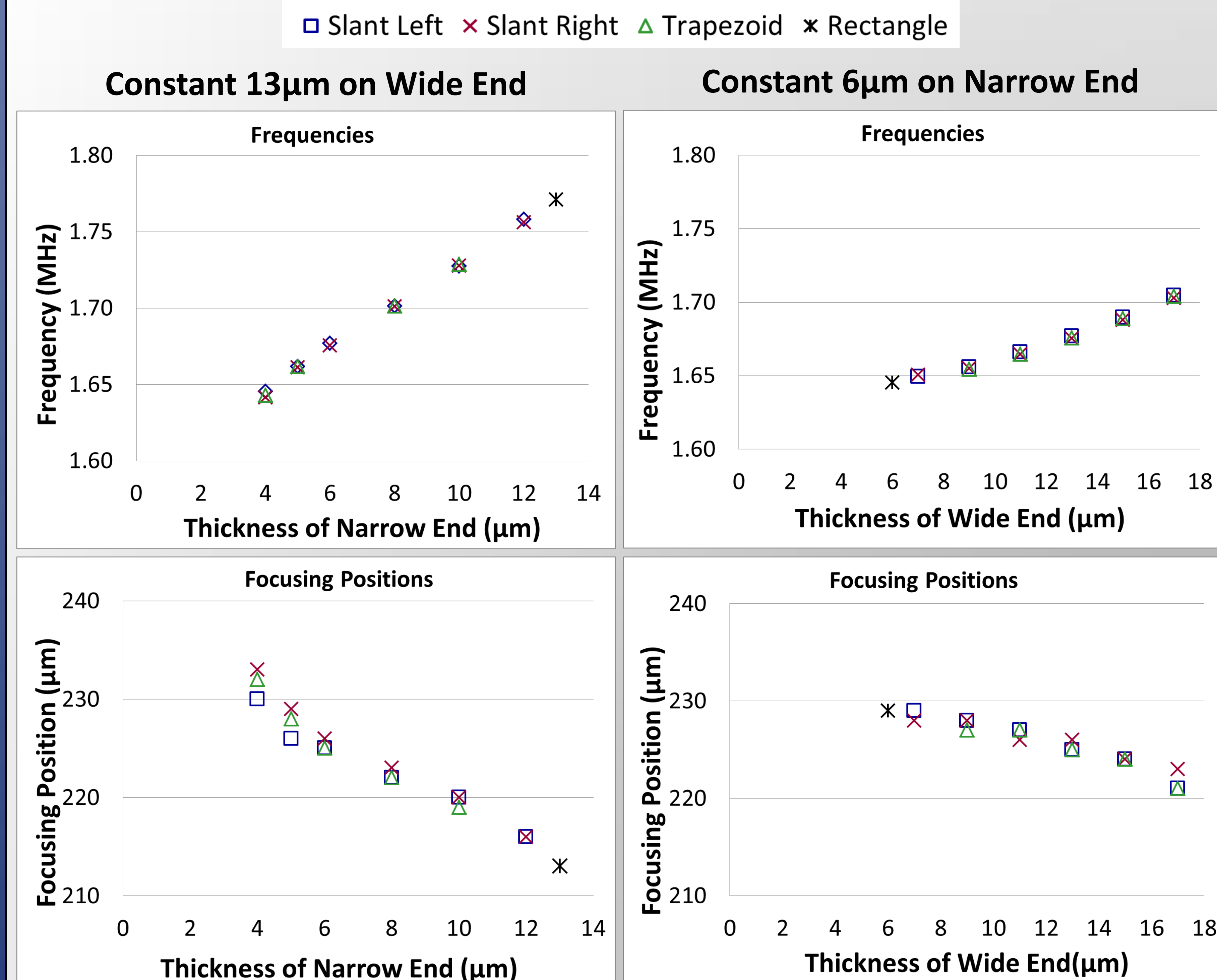


- 2D simulations performed using COMSOL Multiphysics solving for eigenfrequencies in Pressure Acoustics Model
- Both channels filled with water
- Varied wall shape and dimensions around actual dimensions measured from SEM - 13 μm at wide end, 6 μm at narrow end



- Focusing position is location of minimum pressure
- Focusing frequency taken directly from COMSOL

Results



Discussion

- Focusing frequency is insensitive to wall shape
- Focusing position is sensitive to wall shape
- Focusing frequency is sensitive to wall thickness
- Wall position and orientation have minimal effect
- Generally, for every 1 μm change in one of the wall thickness dimensions:
 - Focusing position moves 1-2 μm
 - Focusing frequency shifts 5-10 kHz
 - Changes are more severe when wall asymmetry is greater

Conclusions

As the overall wall thickness increases, focusing frequency increases and focusing position moves farther from the wall. Focusing frequency is not affected by the shape of the wall.

Further Questions

- How do these results compare with the experiment?
- How do wall variations affect strength of focusing?
- How does a 3D simulation of the entire chip setup compare with the experimental measurements?
- How does shape of the node (curvature) affect focusing?

References

[1] E. J. Fong, A. C. Johnston, T. Notton, S.-Y. Jung, K. A. Rose, L. S. Weinberger, and M. Shusteff, "Acoustic focusing with engineered node locations for high-performance microfluidic particle separation," *Analyst*, vol. 139, no. 5, pp. 1192–1200, Feb. 2014.

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