Pillar Density Modulation in a Semi-Packed MEMS Column

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Rundown

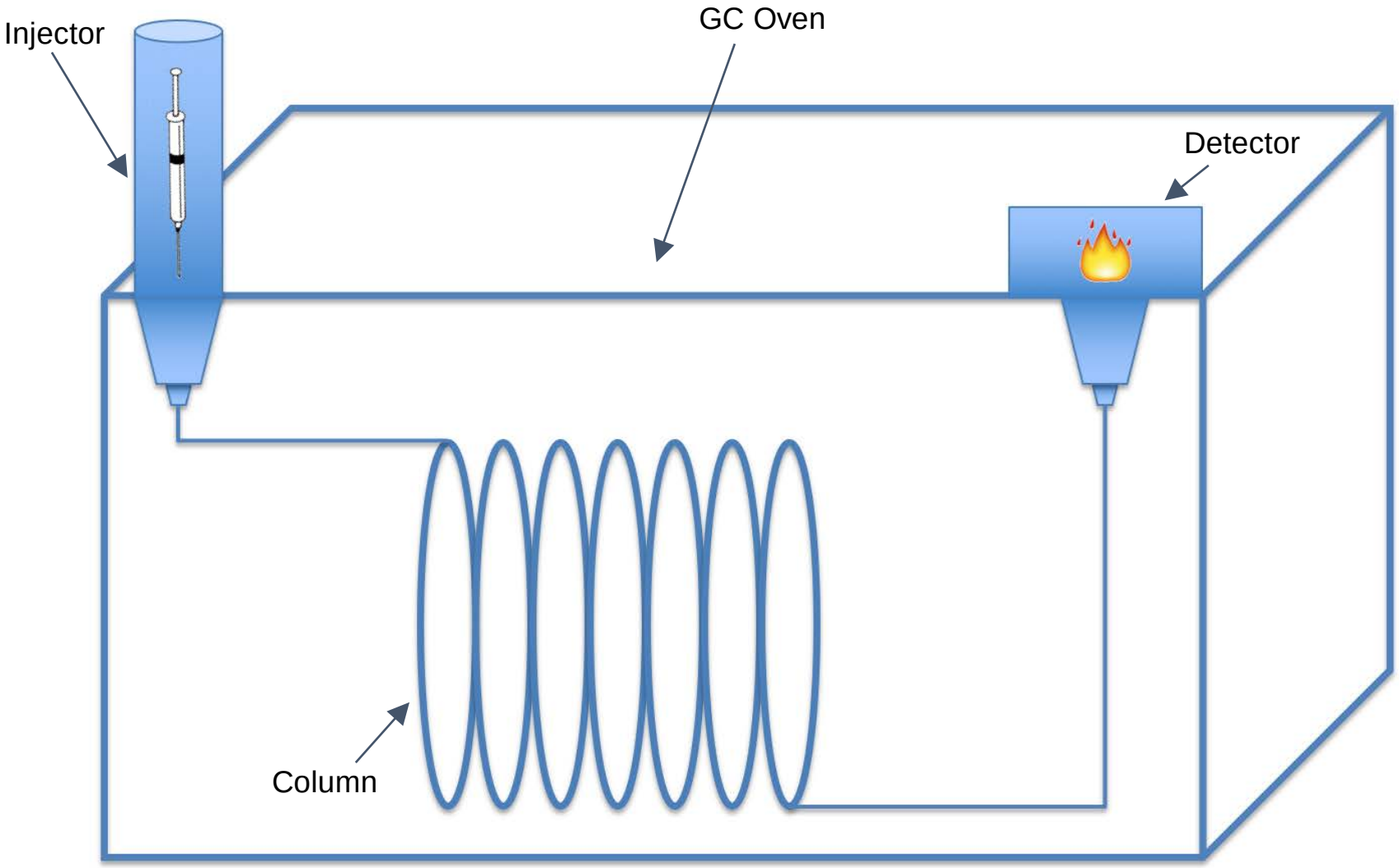
- Background information
- Breakdown of new design
- Experimental results
- Conclusion

Gas Chromatography

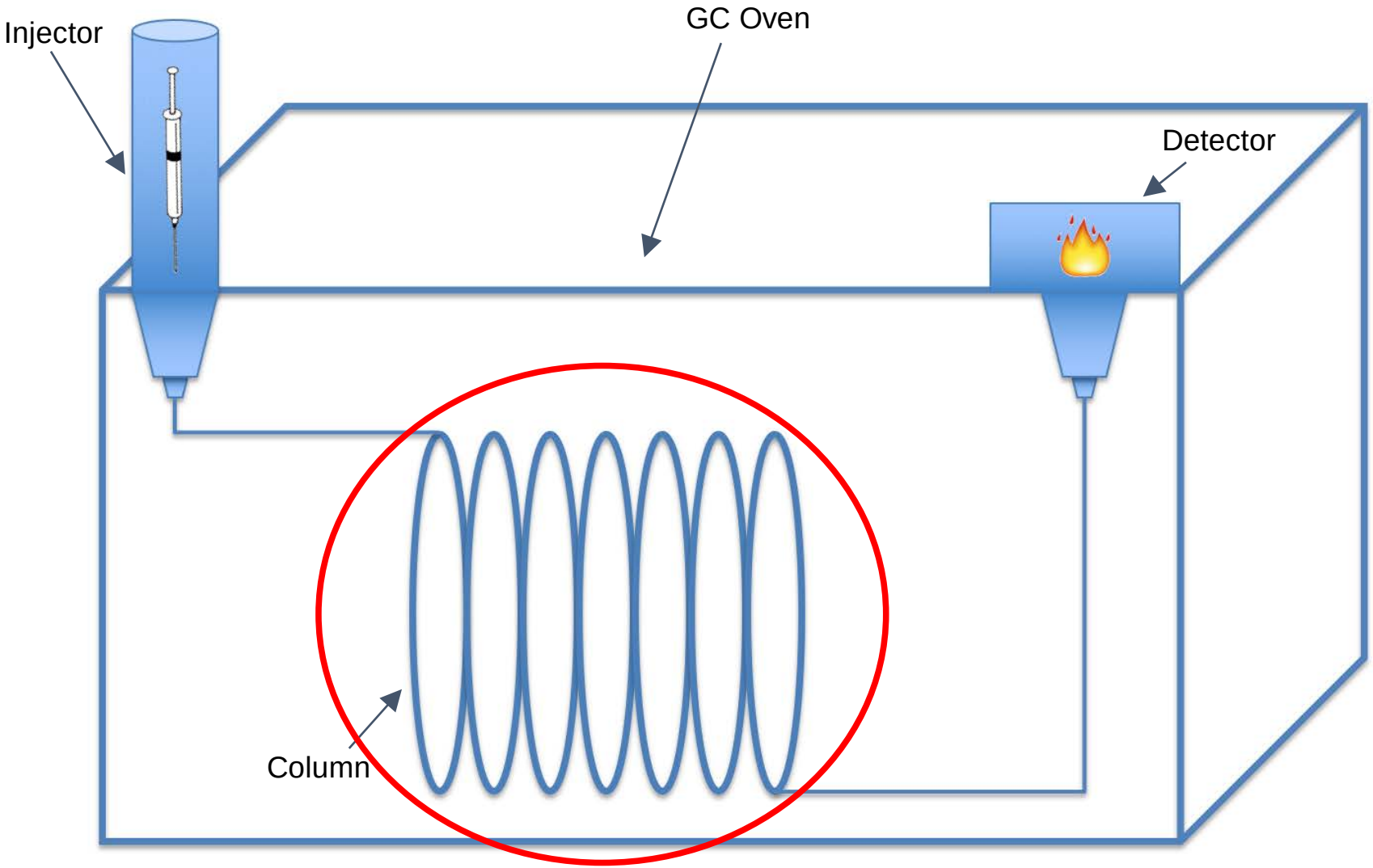
Why is gas chromatography important?

- Allows analyzation of individual analytes from a single sample
- Analysis of ambient environment in real time
  - Status of food
  - Medical applications

GC System

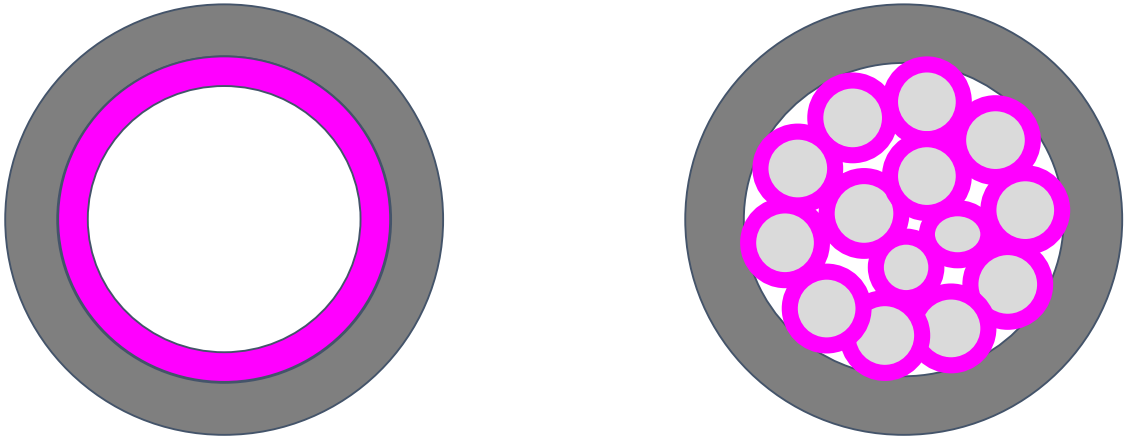


GC System



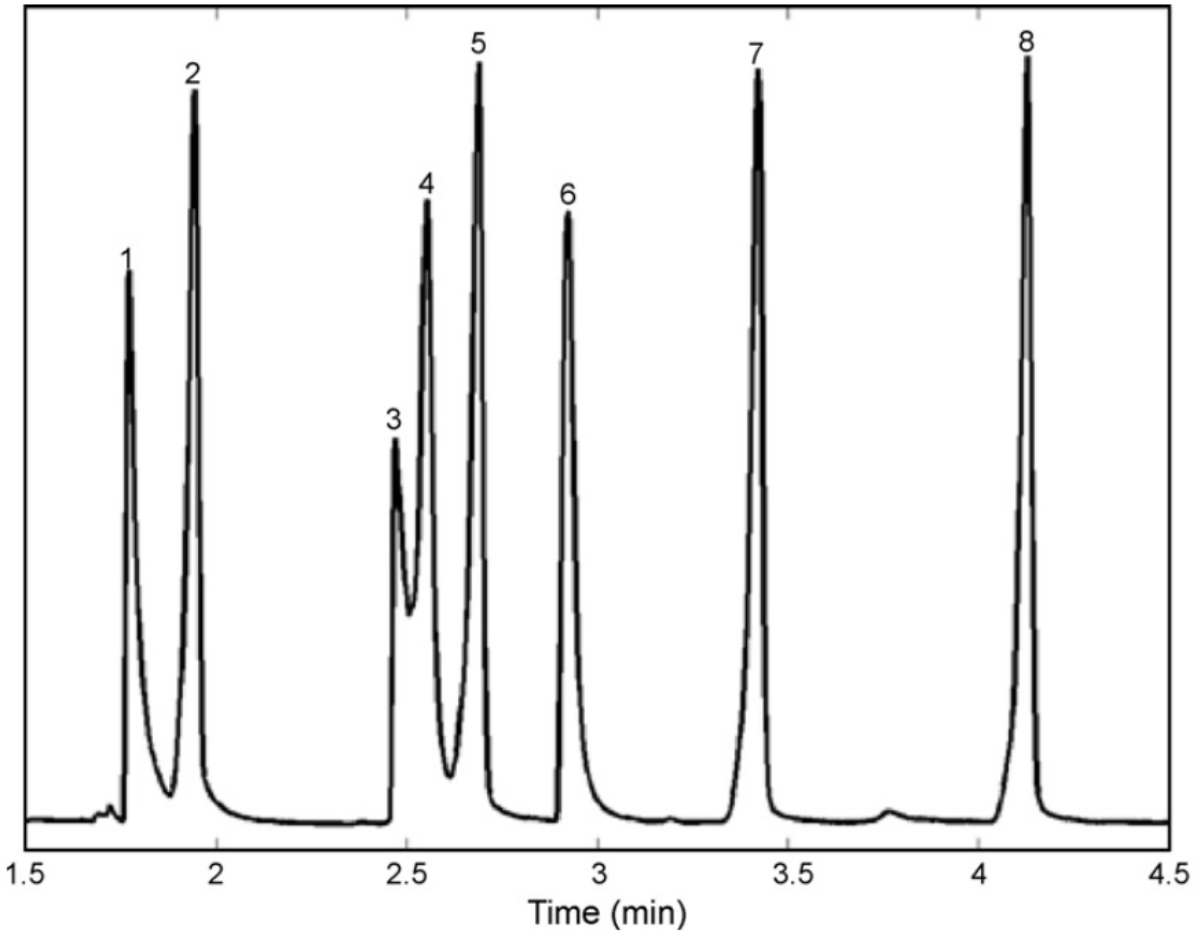
Column Characteristics

- Open vs. Packed



- Stationary Phase
  - Dictates the interaction between column and sample
    - Polarity
    - Film thickness

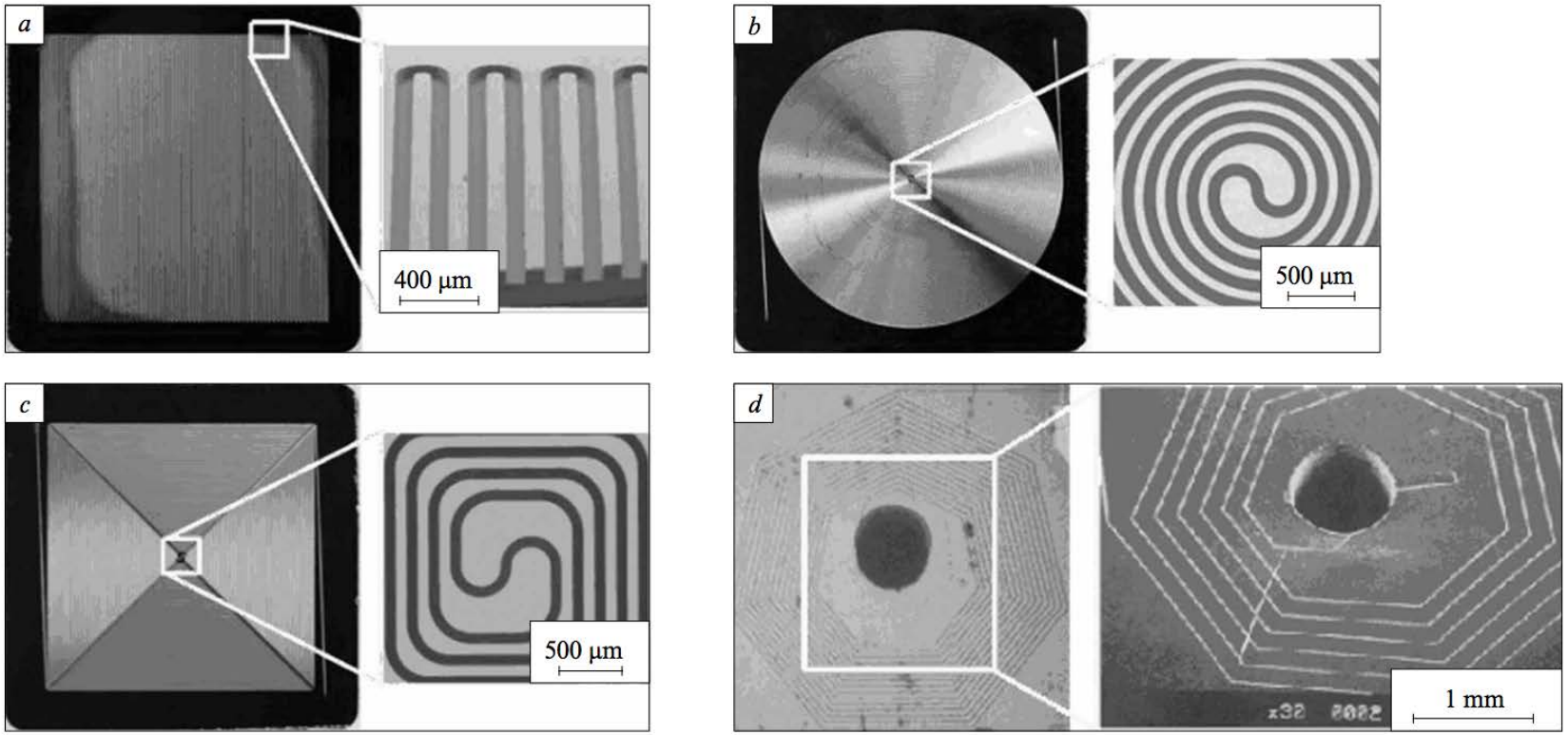
Separation Results



	Component
1	2-Octanone
2	Decane
3	1-Octanol
4	2,6-Dimethylphenol
5	Undecane
6	2,6-Dimethylaniline
7	Dodecane
8	Tridecane

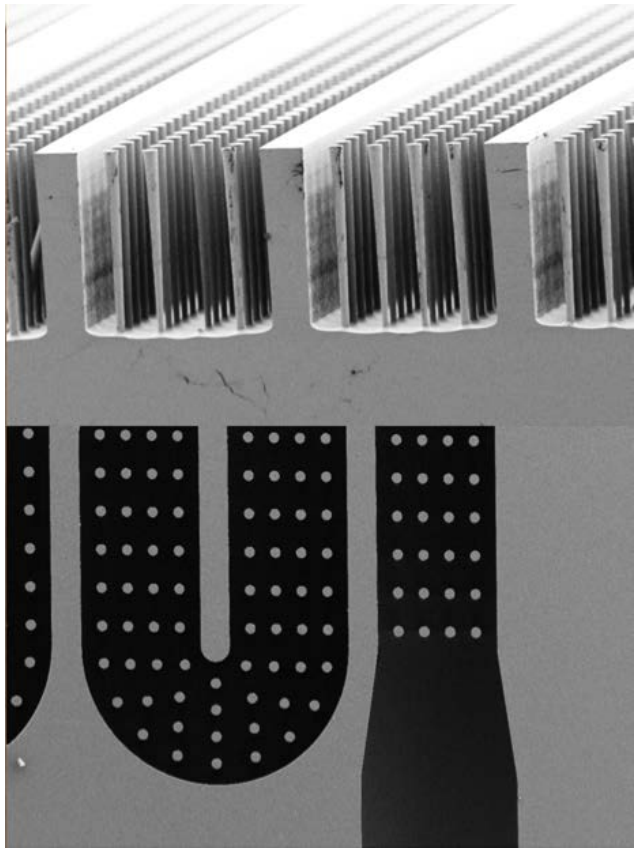
Ali, Syed, Mehdi Ashraf-Khorassani, Larry T. Taylor, and Masoud Agah. "MEMS-Based Semi-Packed Gas Chromatography Columns." *Sensors and Actuators B: Chemical* 141, no. 1 (August 18, 2009): 309–15. doi:10.1016/j.snb.2009.06.022.

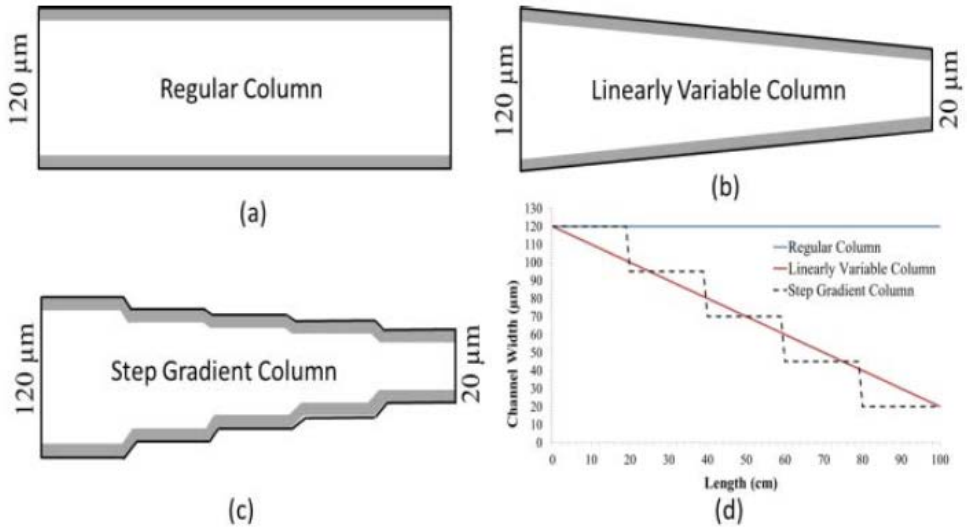
MEMS GC Columns



Sidelnikov, Vladimir N., Olga A. Nikolaeva, Igor A. Platonov, and Valentin N. Parmon. "Gas Chromatography of the Future: Columns Whose Time Has Come." *Russian Chemical Reviews* 85, no. 10 (October 2016): 1033. doi:10.1070/RCR4627.

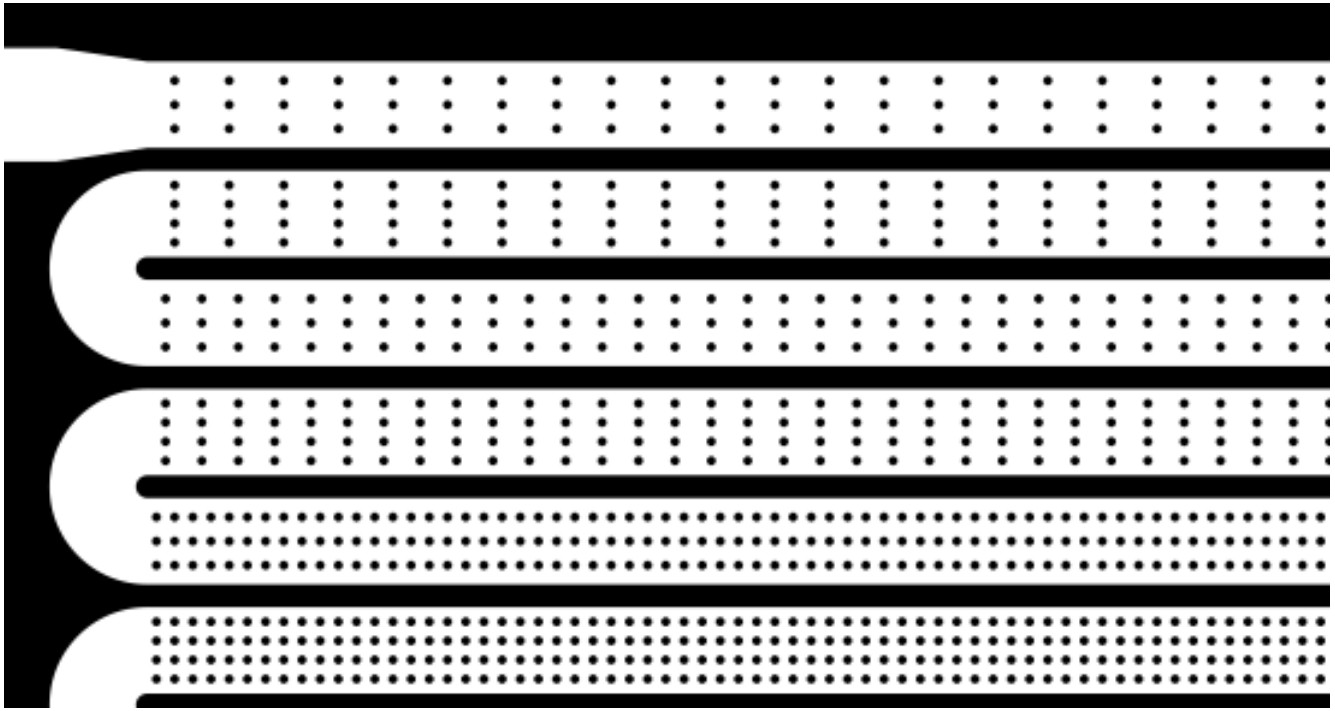
Different Column Variations





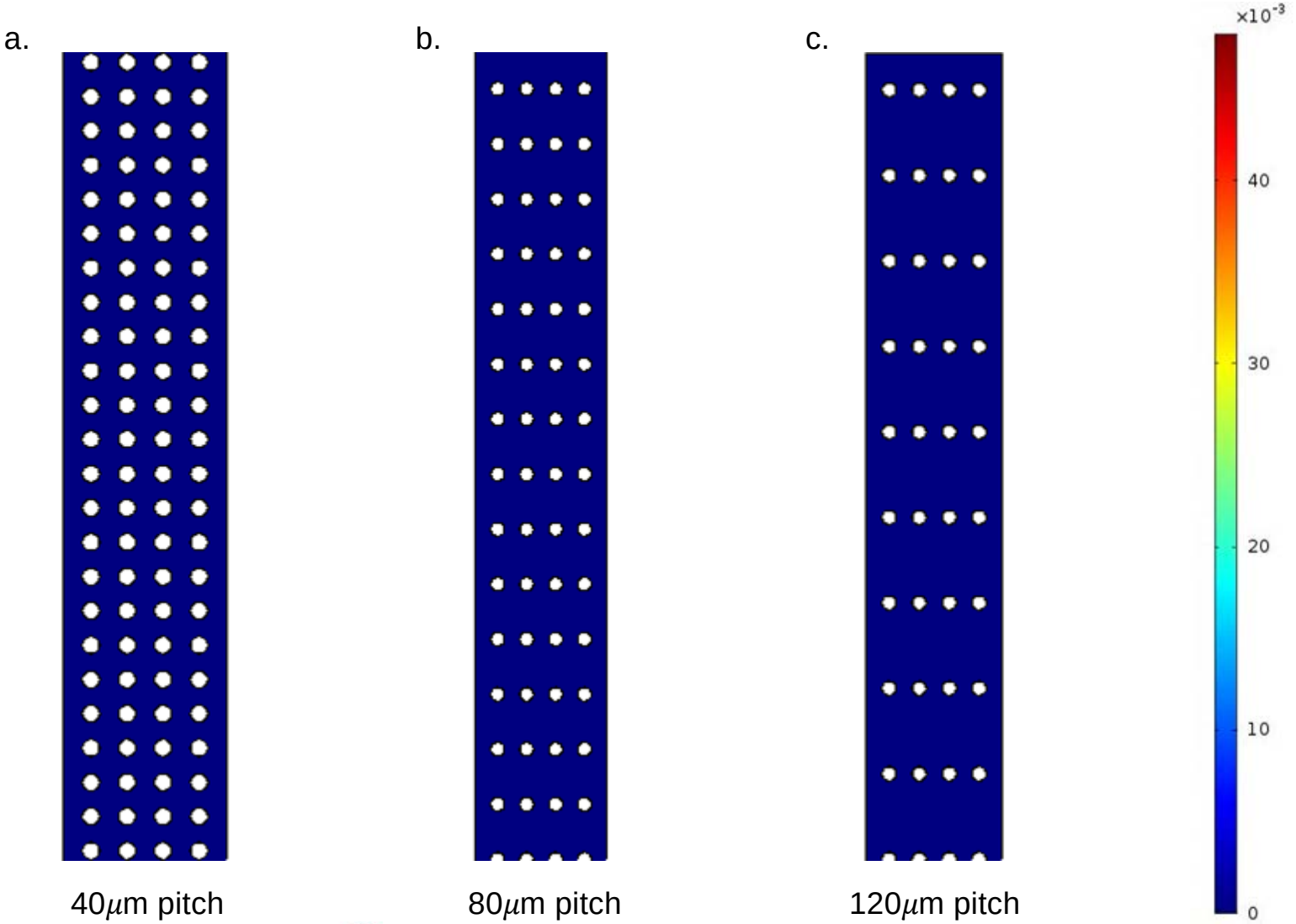
Shakeel, H., D. Wang, J. R. Heflin, and M. Agah. "Width-Modulated Microfluidic Columns for Gas Separations." *IEEE Sensors Journal* 14, no. 10 (October 2014): 3352–57. doi:10.1109/JSEN.2014.2326593.

Pillar Density Modulation



a. 3 pillars, 120μm pitch
b. 4 pillars, 120μm pitch
c. 3 pillars, 80μm pitch
d. 4 pillars, 80μm pitch
e. 3 pillars, 40μm pitch
f. 4 pillars, 40μm pitch

Simulations of pillar pitches

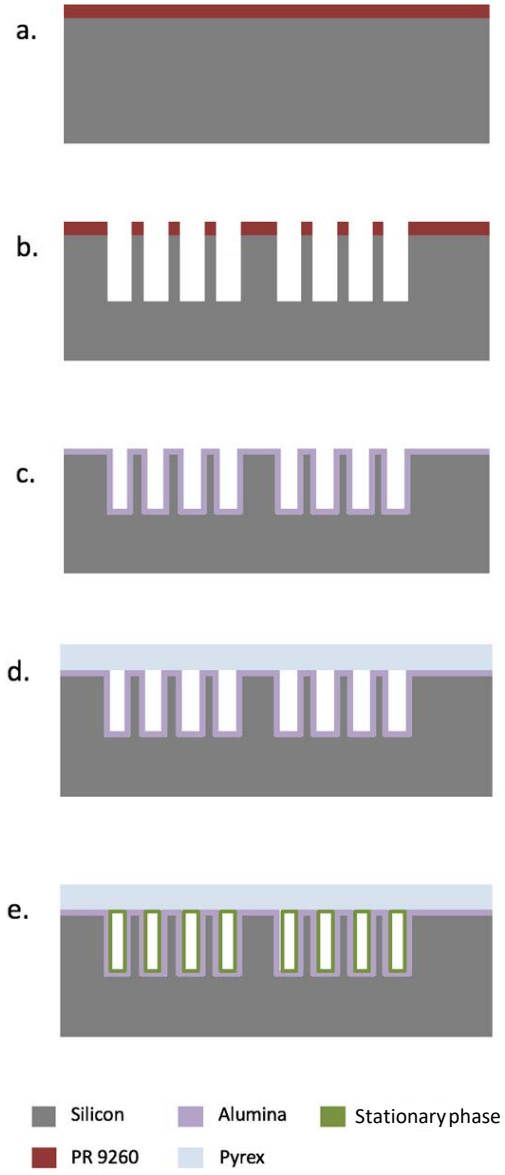


40μm pitch

80μm pitch

120μm pitch

Fabrication Process Flow



a. Spin photoresist and perform photolithography

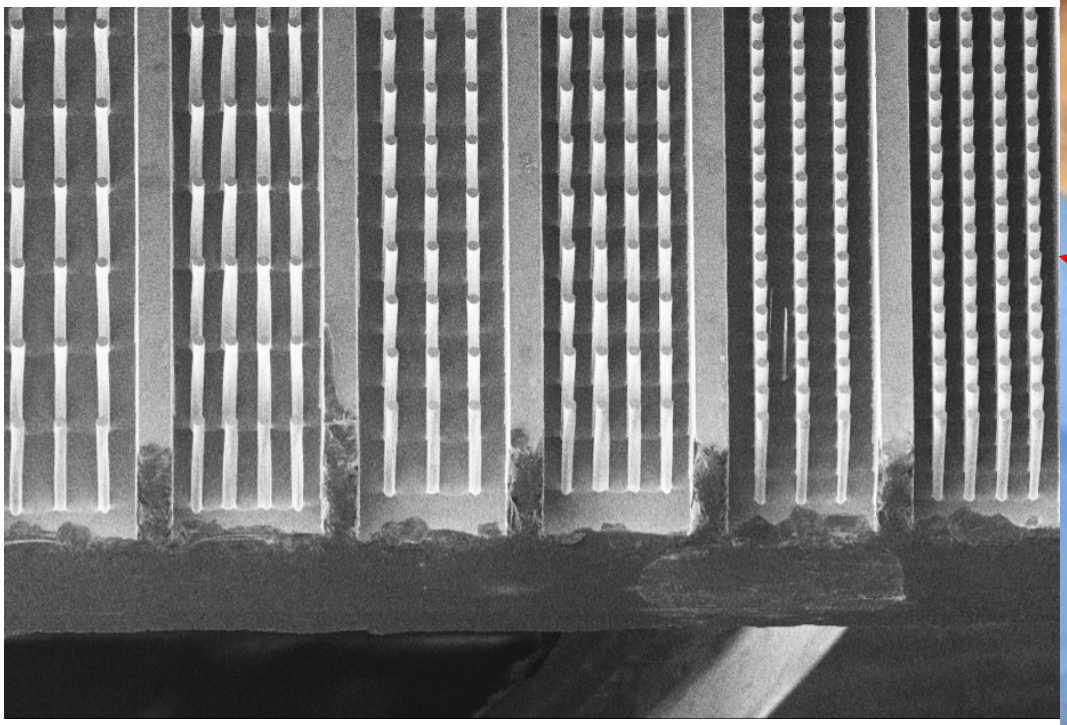
a. Etch the channel for the column utilizing deep reactive ion etching (DRIE)

a. Grow thin film of alumina using atomic layer deposition (ALD)

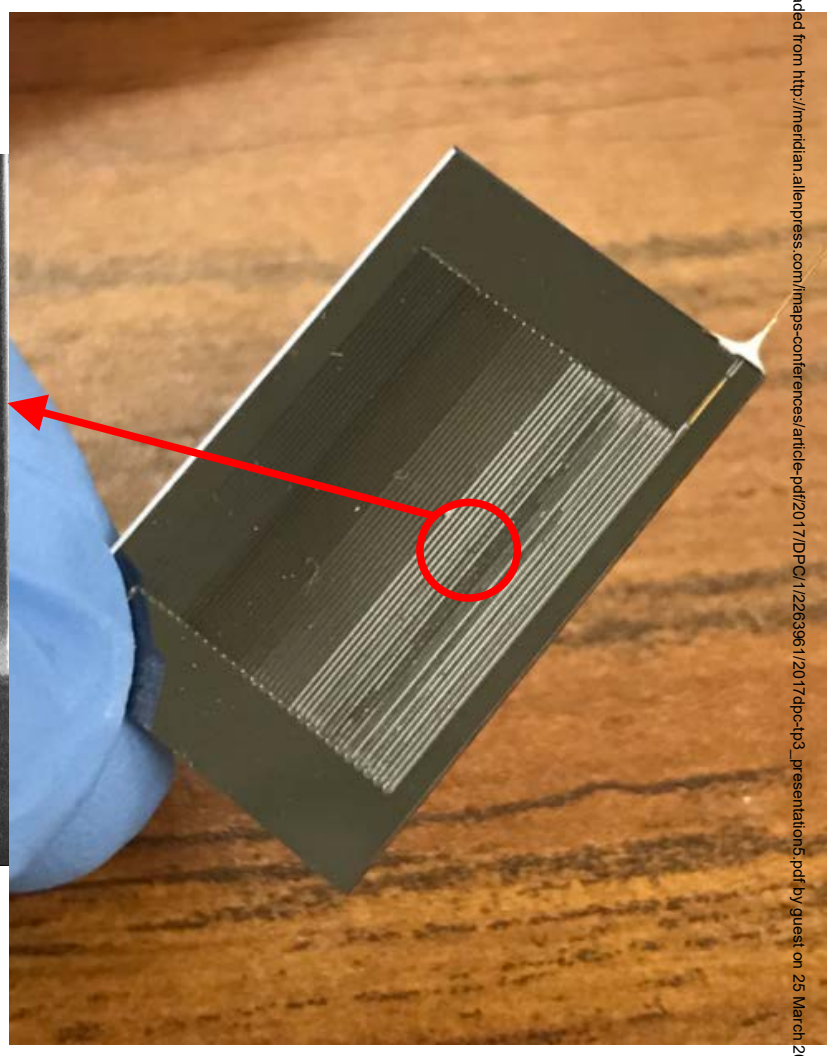
a. Bond Pyrex wafer to silicon substrate to create airtight seal

a. Functionalize column with stationary phase

Images of Device



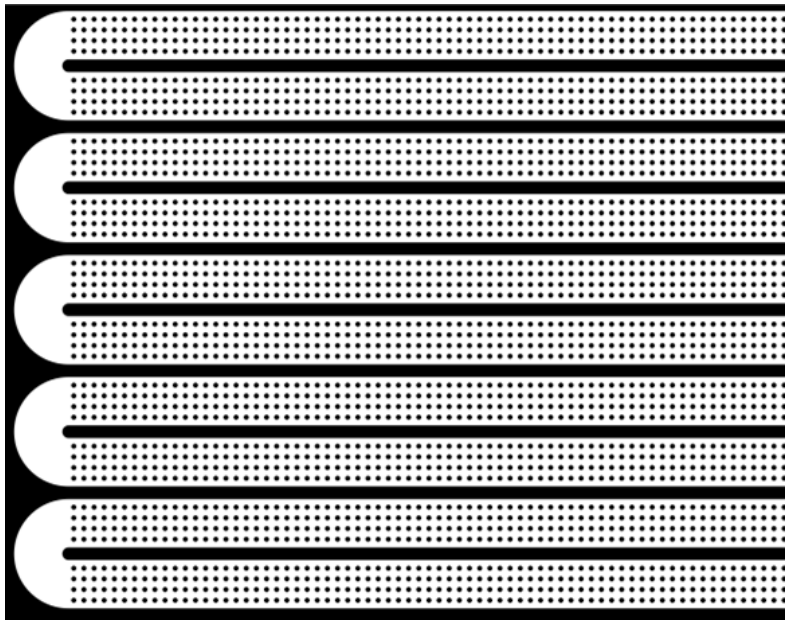
SEM image of uncoated column



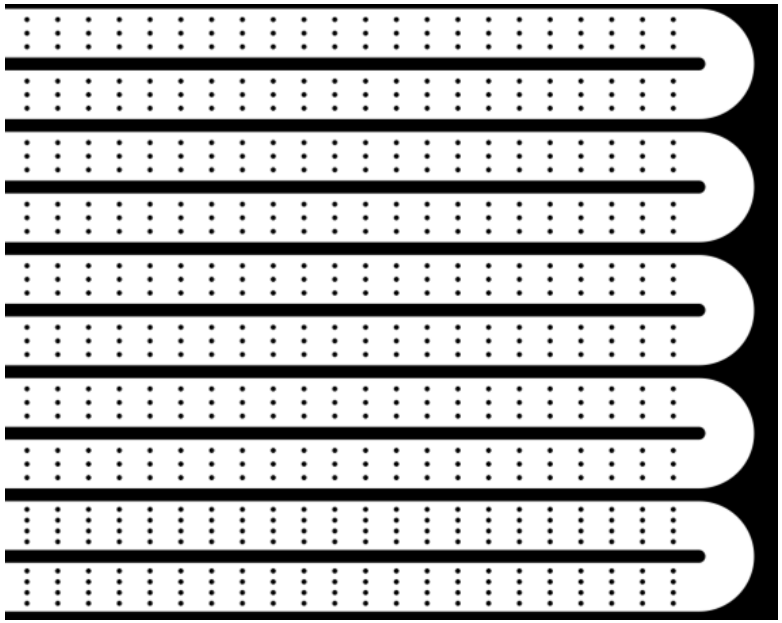
Optical image of finished device

Control Designs

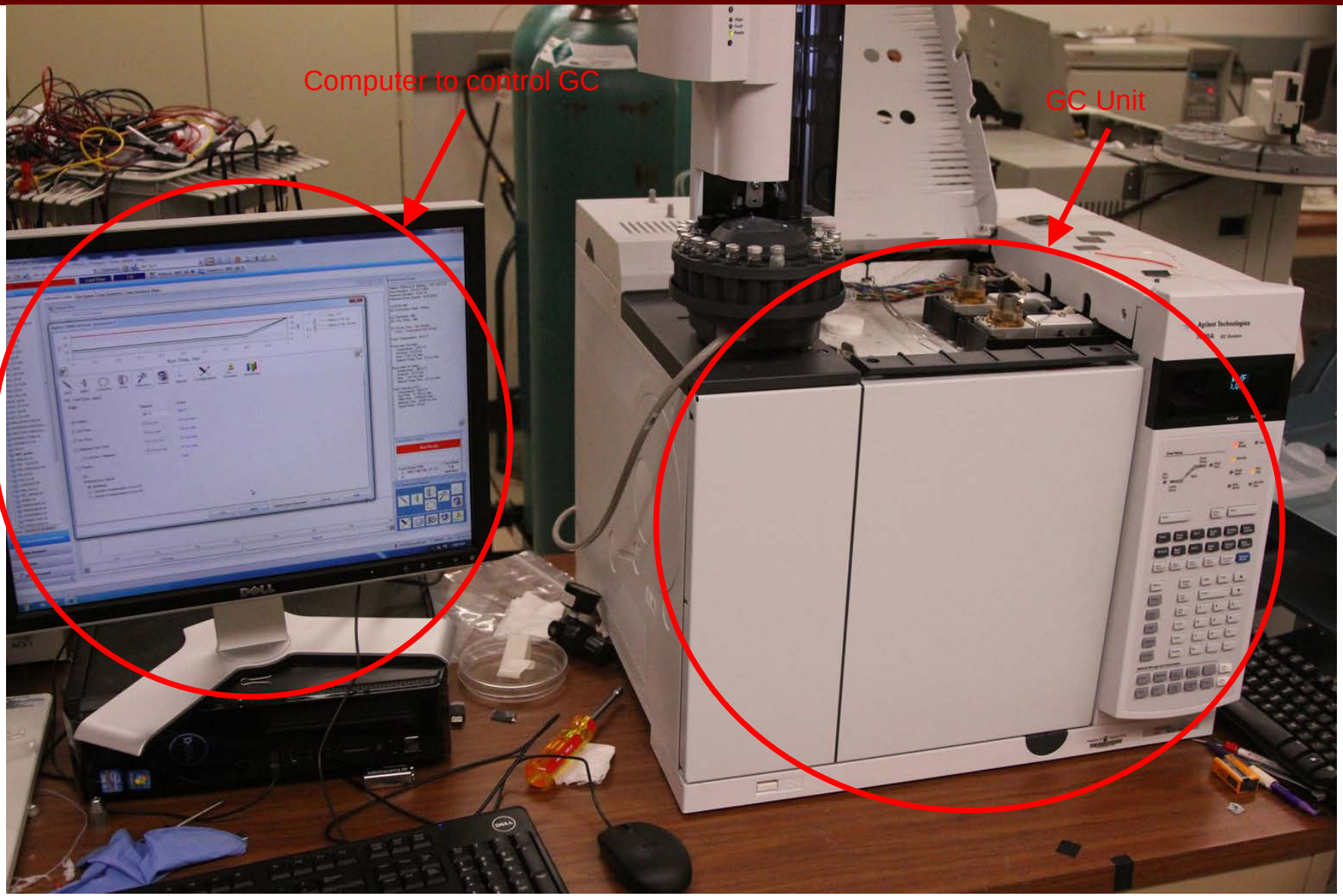
Max Density



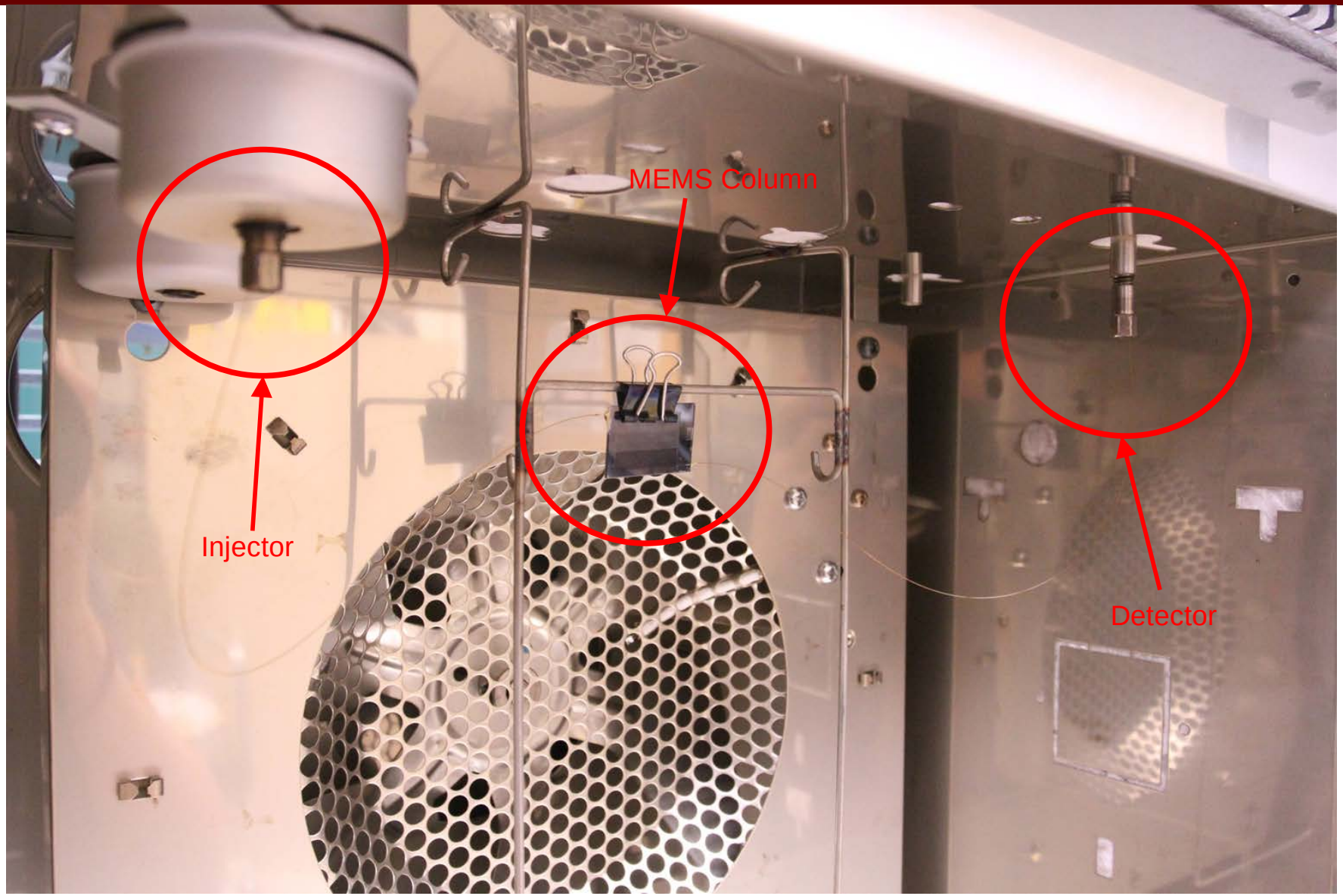
Minimum Density



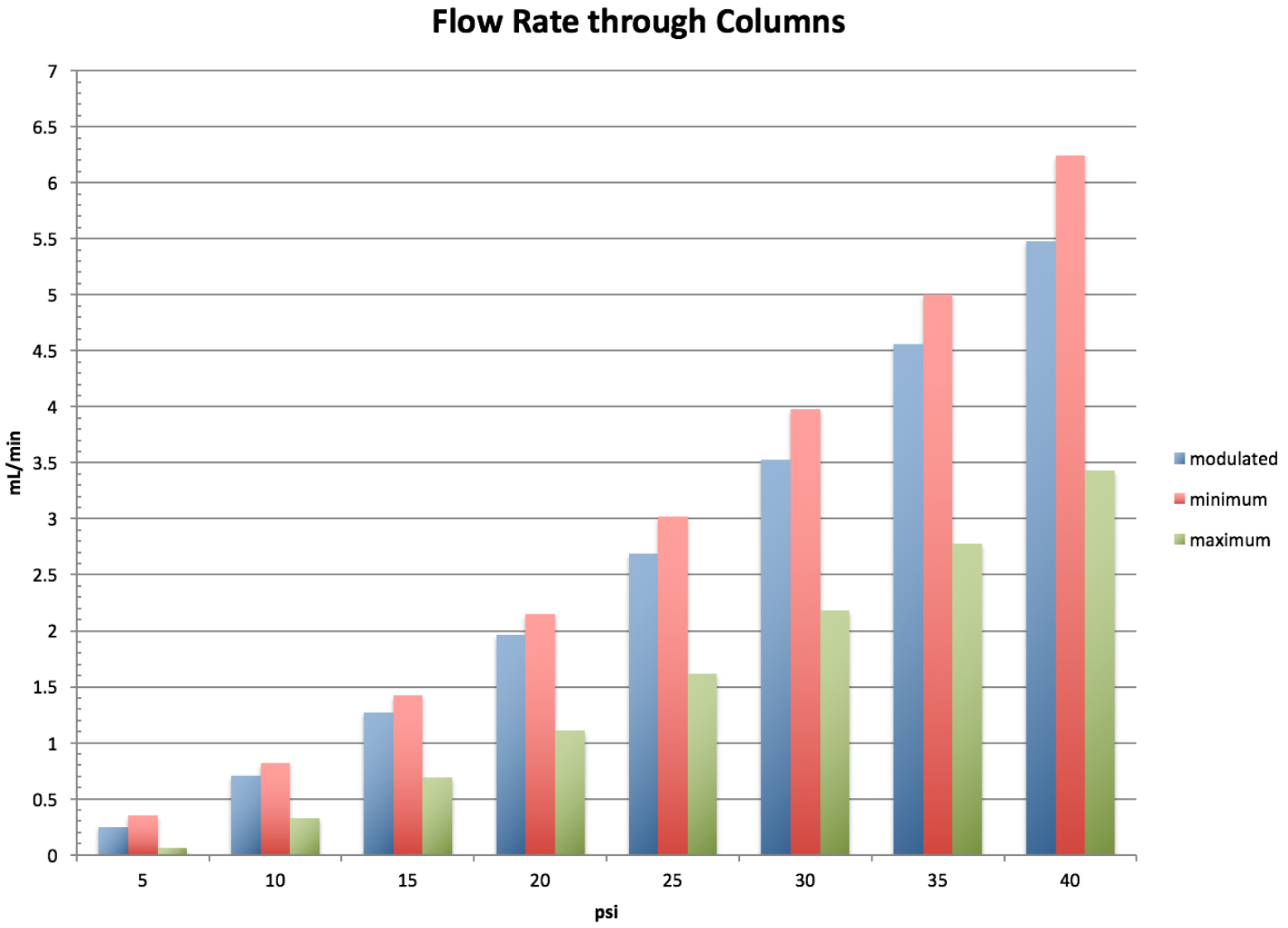
Experimental Setup



Experimental Setup



Results



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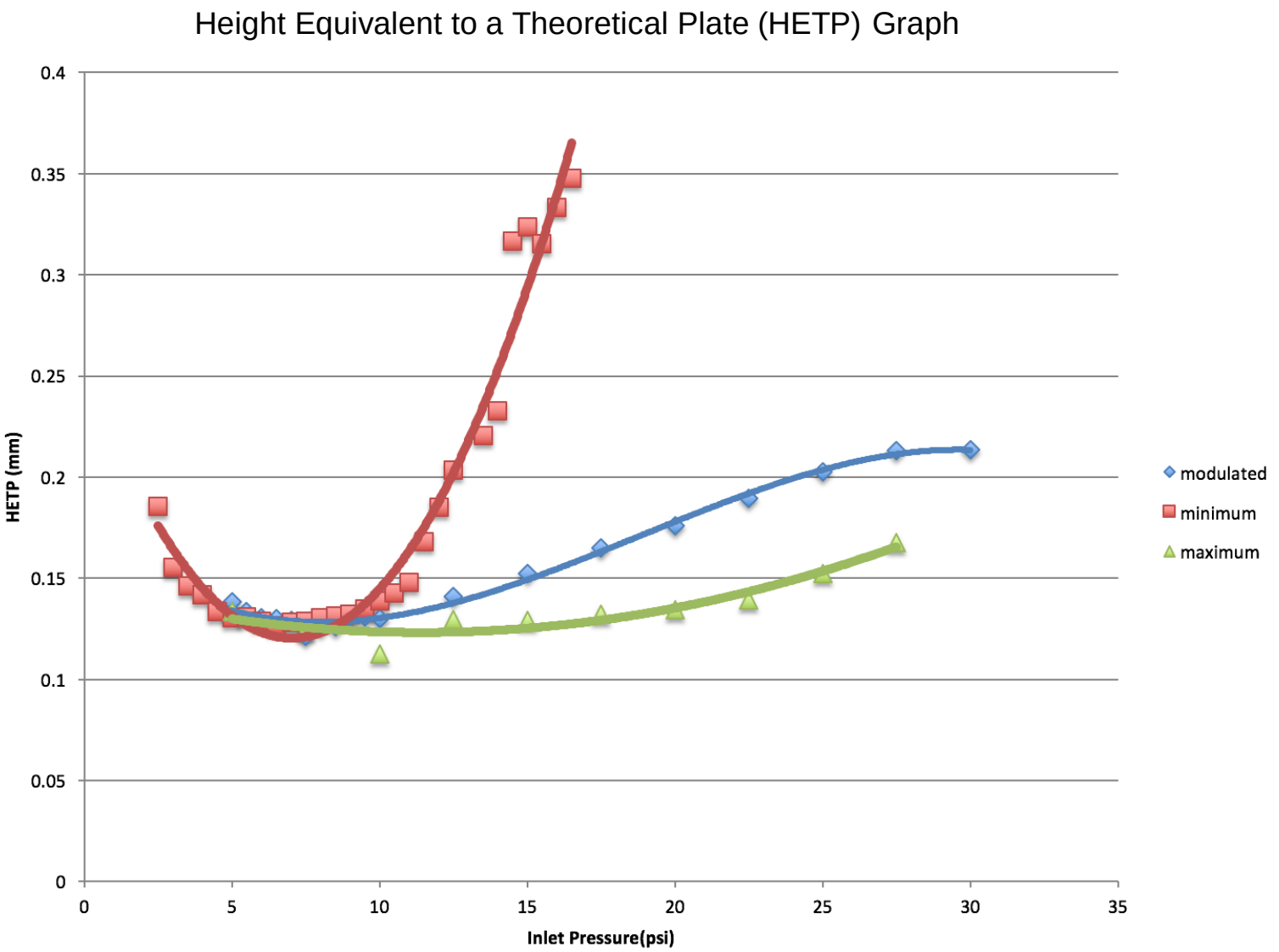

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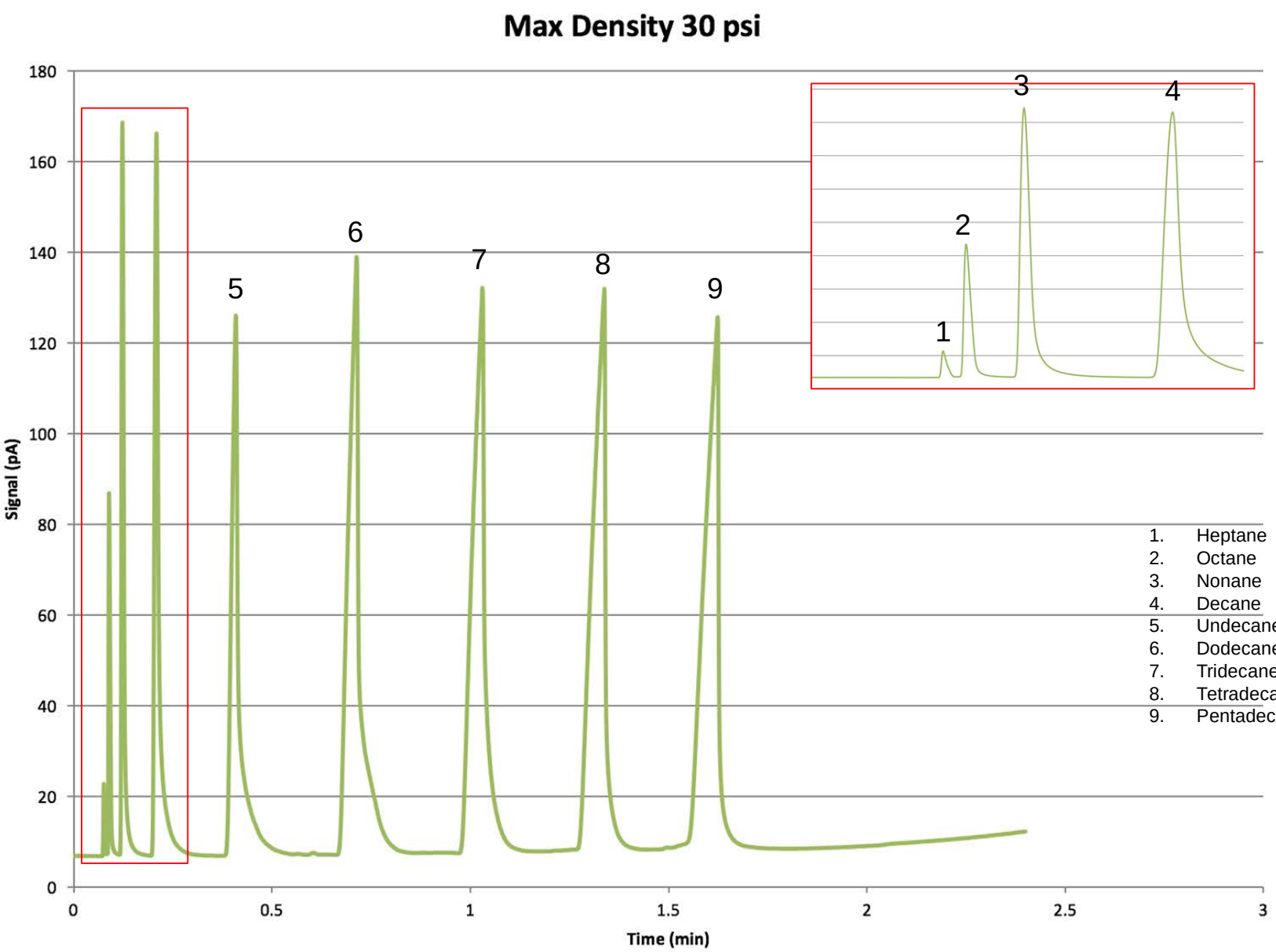
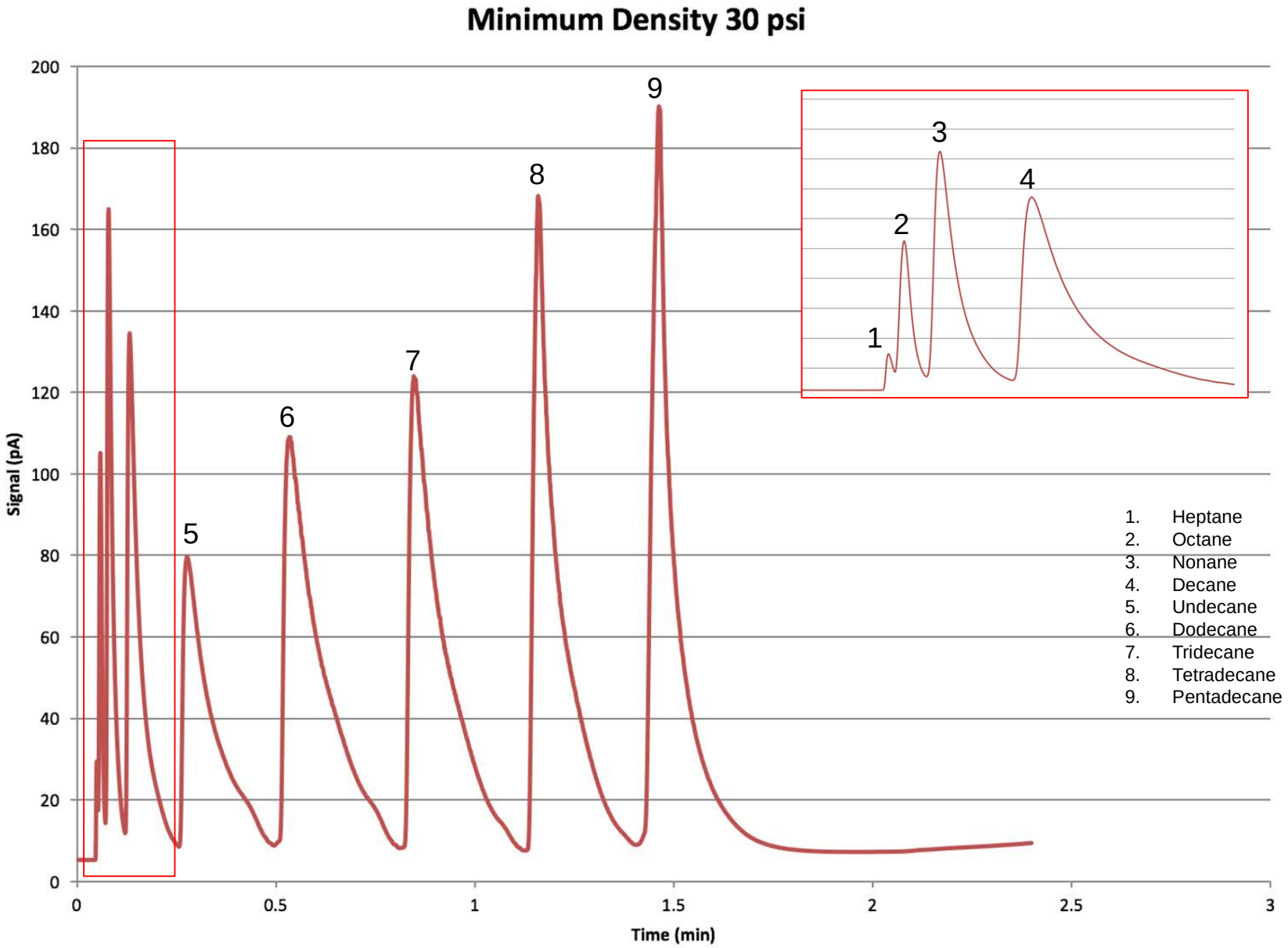


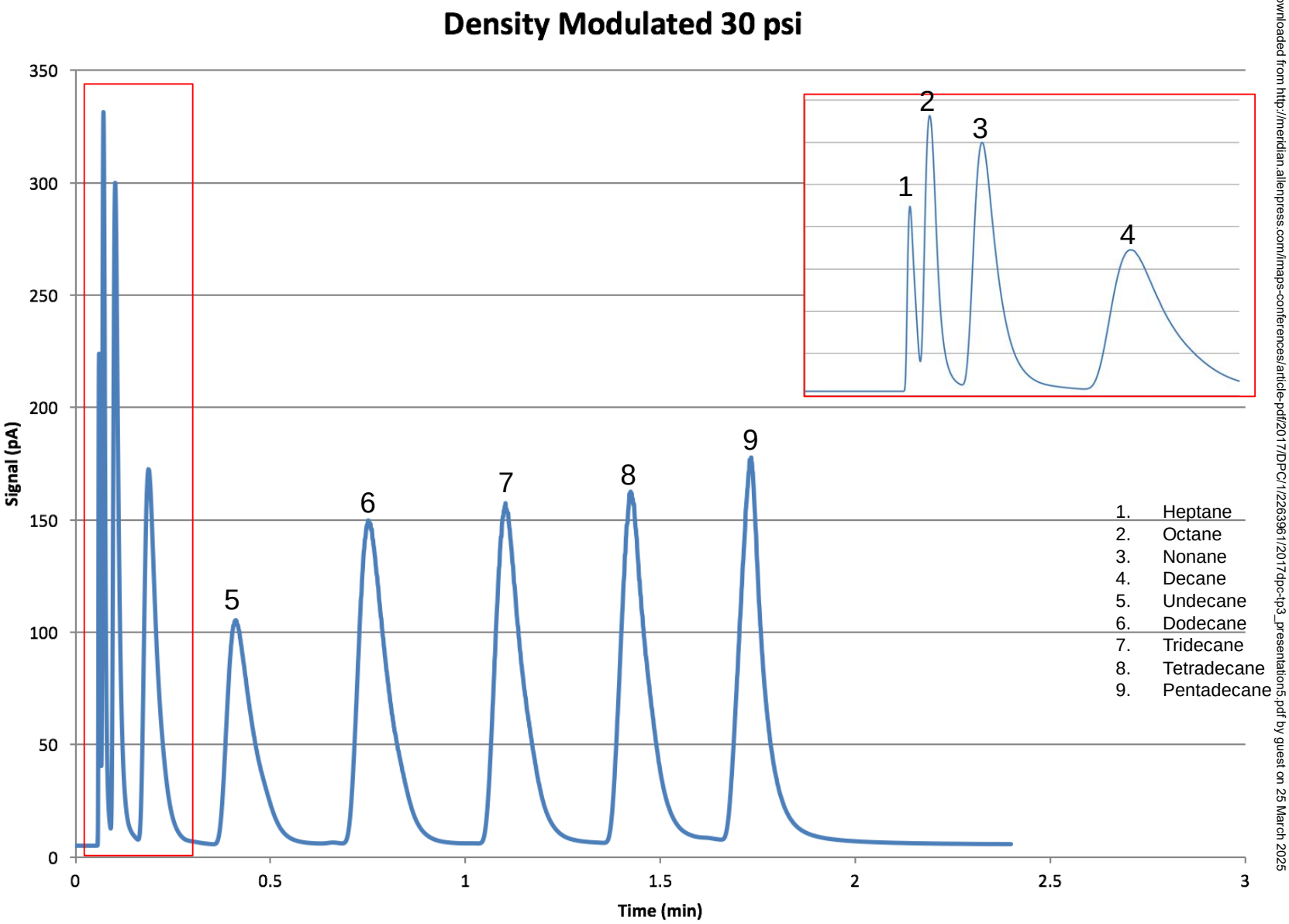
30 psi inlet pressure with temperature programming of 30-120C at 40C/min

Results



30 psi inlet pressure with temperature programming of 30-120C at 40C/min

Results



30 psi inlet pressure with temperature programming of 30-120C at 40C/min

Conclusions

- Density Modulated design has a lower pressure drop across the column than the maximum design
- However, it does not lose out on separation efficiency like the minimum design (HETP)
- Separation results show that further optimization is possible
- Could lead to improvements in high speed separations (less than a minute)