# DNA in Nanochannels

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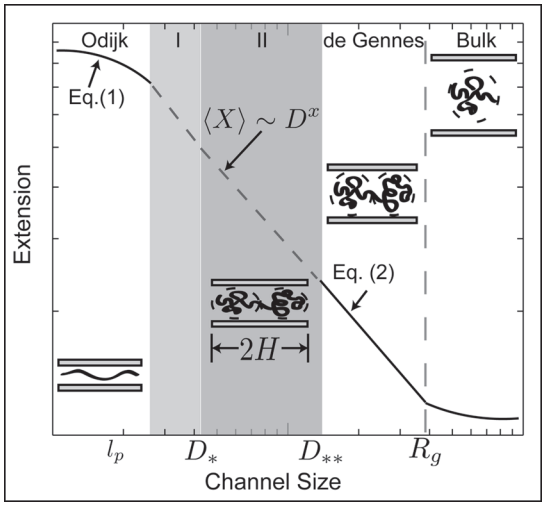


*Figure 1: Illustration of Odjik and de Gennes regimes and possible other extensions as a function of channel size. Reprinted with permission from [3]. Copyright August 1, 2011, ACS.*

## Abstract and Introduction:

Deoxyribonucleic acid (DNA) is an important part of biological studies to understand diseases and evolution. By placing DNA in nanochannels, we have a top down approach to study DNA that can lead to the fabrication of chip-based devices that can detect and separate single DNA molecules by length. By placing DNA in nanochannels, however, the Brownian dynamics is different than that of DNA in a bulk solution [1]. Further understanding of DNA in confined areas is fundamental for chip design. By making nanochannels of varying channel sizes, we can show how DNA's extension varies with channel size and how that changes the Brownian dynamics of DNA. Figure 1 shows how DNA's extension is affected by channels size. There are two well-described regimes in Figure 1, Odjik and de Gennes.

In Odjik's regime, the channel size is smaller than DNA's persistence length and behaves as a stiff chain. In de Gennes's regime, the channel size is smaller than the radius of gyration, and DNA behaves like linked blobs. Based on evidence from computer simulations on different channel sizes, there are two transition regimes between the Odjik and de Gennes regimes [2]. Since DNA is a large polymer, any fundamental property, we find on DNA can also be extrapolated down to smaller polymers.

## Methods:

The goal of this project was to fabricate nanochannels of varying widths to experimentally observe the behavior of DNA in confined spaces, and relate them to the theoretical data.

Electron beam lithography is a great way to make nanochannels of varying widths, but is very costly. By implementing optical photolithography, we can achieve the same goal at a cheaper price. Figure 2 shows how the whole process was carried out. The problem with optical photolithography though was that we could only achieve nanochannels widths of about 500 nm after reactive ion etching. We wanted to reach nanochannels of about 100 nm to 700 nm. In order to achieve that, we used plasma enhanced chemical vapor deposition (PECVD) to deposit oxide on the channels to make them thinner. By placing the channels in the PECVD for 16 minutes in three 5 min 20 s intervals,

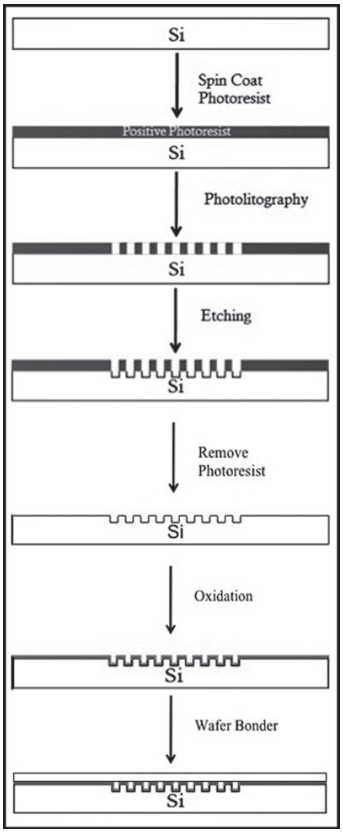


*Figure 2: Process to make nanochannels.*

we shrank the 500 nm channels down to 150 nm, and the 750 nm channels down to 450 nm.

In order to get DNA inside the channels, reservoirs were placed in the silicon wafer. A potassium hydroxide bath etched rectangles through the silicon wafer. To complete the prototype, we used a substrate bonder to bond glass on top of the silicon wafer. The glass provided a transparent material to observe the DNA under a microscope.

To see the DNA under the microscope, we dyed the DNA with YOYO, an intercalating dye that fluoresces green when exposed to blue light. To make the DNA travel across to the channels, we used an electric field to drive the DNA toward the channels from the reservoir. This worked because we placed two electrodes and applied a voltage potential between the two. The oxide provided an insulating layer and the current could only travel through the salts of the buffer solution. Since DNA is negatively charged due to the phosphate groups along the backbone, DNA travels toward the positively charged electrode.

## Results and Discussion:

After making the prototype, it was really important to see if DNA would travel into the channels by the methods described above. In the first attempt, the DNA kept sticking to the oxide walls of the microchannels leading up to the nanochannels. Because of the sticking, the DNA never made it to the nanochannels. To counteract this problem, we let the prototype sit in a polymer solution of polyvinylpyrrolidone (PVP) over a time period of over 48 hours. PVP coated the oxide walls of the channels and prevented the DNA from sticking to the sidewalls.

Figure 3 shows the nanochannels under a brightfield microscope. Figure 4 shows the same channels, but under a blue light that shows the DNA fluorescing in the channels. This is significant because this shows that DNA can be placed inside the channels and with that, we can experimentally study the behavior of DNA in confined spaces.

By making different channel sizes, we can observe their extension and diffusivity coefficients based on a variety of channel size.


## Acknowledgements:

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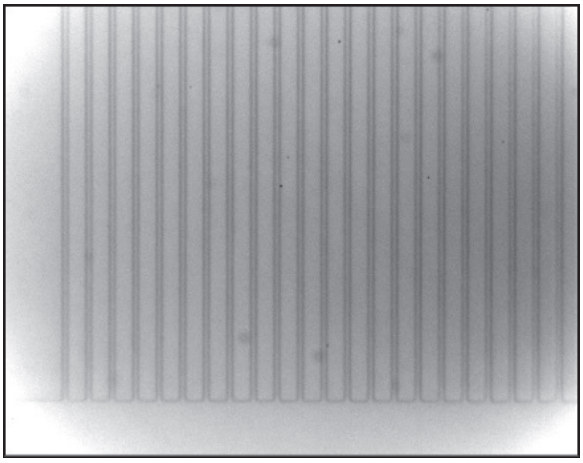

*Figure 3: Channels under brightfield microscope.*

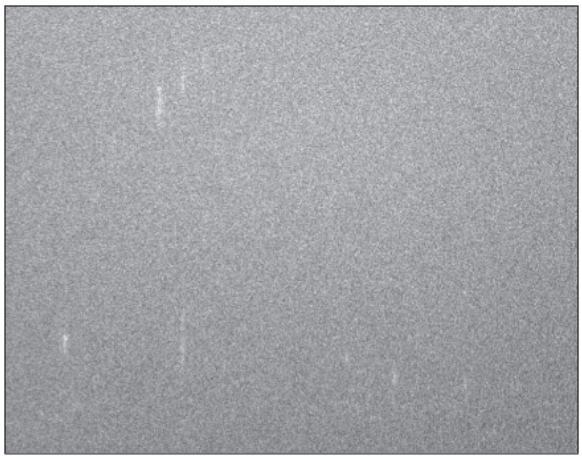

*Figure 4: Channels under blue light, showing the DNA fluorescing in the channels.*