

MANIPULATING FLUIDS: ADVANCES IN  
MICRO-FLUIDICS, OPTO-FLUIDICS AND  
FLUIDIC SELF ASSEMBLY

Thesis by

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*The efforts of most human-beings are consumed in the struggle for their daily bread, but most of those who are, either through fortune or some special gift, relieved of this struggle are largely absorbed in further improving their worldly lot. Beneath the effort directed toward the accumulation of worldly goods lies all too frequently the illusion that this is the most substantial and desirable end to be achieved; but there is, fortunately, a minority composed of those who recognize early in their lives that the most beautiful and satisfying experiences open to humankind are not derived from the outside, but are bound up with the development of the individual's own feeling, thinking and acting. The genuine artists, investigators and thinkers have always been persons of this kind. However inconspicuously the life of these individuals runs its course, none the less the fruits of their endeavors are the most valuable contributions which one generation can make to its successors....*

**-Albert Einstein in Emmy Noether's obituary (1935)<sup>1</sup>**

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<sup>1</sup> Quote in my graduate school application, circa 2001. I am happy to report that grad school has not blunted this belief, as yet.

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## ABSTRACT

This dissertation describes work in three inter-related areas – micro-fluidics, opto-fluidics and fluidic self-assembly. Micro-fluidics has gotten a boost in recent years with the development of multilayered elastomeric devices made of poly (dimethylsiloxane) (PDMS), allowing active elements like valves and pumps. However, while PDMS has many advantages, it is not resistant to organic solvents. New materials and/or new designs are needed for solvent resistance. I describe how novel fluorinated elastomers can replace PDMS when combined with the three dimensional (3-D) solid printing. I also show how another 3-D fabrication method, multilayer photo-lithography, allows for fabrication of devices integrating filters. In general, 3-D fabrications allow new kinds of micro-fluidic devices to be made that would be impossible to emulate with two dimensional chips.

In opto-fluidics, I describe a number of experiments with quantum dots both inside and outside chips. Inside chips, I manipulate quantum dots using hydrodynamic focusing to pattern fine lines, like a barcode. Outside chips, I describe our attempts to create quantum dot composites with micro-spheres. I also show how evaporated gold films and chemical passivation can then be used to enhance the emission of quantum dots.

Finally, within fluids, self assembly is an attractive way to manipulate materials, and I provide two examples: first, a DNA-based energy transfer molecule that relies on quantum mechanics and self-assembles inside fluids. This kind of molecular photonics mimics parts of the photosynthetic apparatus of plants and bacteria. The second example of self-assembly in fluids describes a new phenomena - the surface tension mediated self assembly of particles like quantum dots and micro-spheres into fine lines. This self assembly by capillary flows can be combined with photo-lithography, and is expected to find use in future nano- and micro-fabrication schemes.

In conclusion, advances in fluidics, integrating materials like quantum dots and solvent resistant elastomers along with 3-D fabrication and methods of self assembly, provide a new set of tools that significantly expand our control over fluids.

## TABLE OF CONTENTS

Acknowledgements.....	iv
Abstract.....	vi
Table of Contents.....	viii
List of Illustrations and/or Tables .....	xi
Nomenclature .....	xv
<b>Chapter I: Introduction .....</b>	<b>1</b>
1.1 Manipulating Fluids: Overview .....	1
1.2 Organization.....	2
1.3 Contributions .....	3
<b>Chapter II: Elastomeric Microfluidics .....</b>	<b>5</b>
2.1 What is Micro-fluidics? .....	6
2.2 Brief History.....	7
2.3 Soft versus hard materials.....	8
2.4 Basic Fluid properties at the micro scale.....	9
2.5 Micro-fluidic Device Applications .....	10
2.6 Soft Lithography and PDMS .....	12
2.7 Elastomeric Valves and Pumps .....	13
2.8 Shortcomings of PDMS devices .....	16
<b>Chapter III: New Materials and Fabrication Techniques .....</b>	<b>19</b>
3.1 Where new materials are needed .....	19
3.2 Survey of materials .....	20
3.3 Coatings.....	23
3.4 CYTOP.....	23
3.5 Perfluoro elastomers.....	26
3.6 PFPE.....	26
3.7 SIFEL .....	28
3.8 Outlook on Solvent Resistant Materials .....	30
3.9 Alternate Fabrication Methods .....	31
3.10 3-D Fabrication.....	32
3.11 Solid Printing.....	33
3.12 3-D Hybrid Molds .....	38
3.13 Acknowledgements .....	41



<b>Chapter IV: Quantum Dots and Optofluidics</b> .....	43
4.1 Introduction.....	43
4.2 Quantum Dots .....	43
4.3 Comparison to Dyes .....	45
4.4 Quantum Dot Composites.....	45
4.5 Quantum Dots inserted Inside Pores.....	46
4.6 Shell Growth .....	47
4.7 Plasmonic interactions with Quantum Dots .....	49
4.8 Enhanced Emission through Chemical Means.....	55
4.9 Opto-fluidics: Hydrodynamic Focusing.....	56
4.11 Writing a Line.....	61
4.12 Spectrofluidic Memory.....	65
4.13 Conclusion and Acknowledgement .....	66
<b>Chapter V: Fluidic Self-assembly: DNA photonics</b> .....	68
5.1 Introduction.....	68
5.2 FRET .....	69
5.3 DNA .....	71
5.4 FRET measurements .....	72
5.5 Bi-FRET 3 dye systems .....	73
5.6 Multi-FRET .....	77
5.7 Modeling.....	80
5.8 Summary and Future Outlook .....	81
5.9 Acknowledgement.....	82
<b>Chapter VI: Fluidic Self Assembly: Capillary flow patterns</b> .....	83
6.1 Self-Assembly by Surface Tension.....	83
6.2 Experiments with BSA .....	84
6.3 Imaging with Quantum Dots and Dyes.....	87
6.4 Other Shapes .....	89
6.5 SEM Imaging .....	90
6.6 Conditions for Line Formation.....	91
6.7 Why are Lines Formed?.....	91
6.8 Other Surfactants and Artificial Pinning Points.....	92
6.9 Adding Particles .....	95
6.10 Discussion.....	97
6.11 Acknowledgement.....	97

**Appendix**.....99  
    A Designing an Elastomeric Microfluidic Chip .....99  
**References**..... 106

## LIST OF ILLUSTRATIONS AND/OR TABLES

<i>Number</i>	<i>Page</i>
<b>2.1</b> Microfluidic Chip .....	5
<b>2.2</b> Annual papers in micro-fluidics .....	7
<b>2.3</b> (table) Scaling of Forces with Length.....	8
<b>2.4</b> (table) Scaling of Physical Properties with Length .....	9
<b>2.5</b> (table) Properties of PDMS .....	12
<b>2.6</b> Multi-layer Soft Lithography .....	13
<b>2.7</b> A Micro-Valve .....	13
<b>2.8</b> Geometry of a Chip .....	14
<b>2.9</b> Top Down and Bottom Up Valves .....	15
<b>2.10</b> Peristaltic Pump .....	16
<b>2.11</b> PDMS Swelling .....	17
<b>3.1</b> Structure of PDMS .....	19
<b>3.2</b> (table) Strength of Bonds.....	21
<b>3.3</b> Steric Effects.....	21
<b>3.4</b> Swelling of Rubbers .....	22
<b>3.5</b> Cytop Structure .....	24
<b>3.6</b> (table) Cytop Structure .....	24
<b>3.7</b> Cytop Coating on PDMS .....	25
<b>3.8</b> (table) Solvent Resistance of PFPE .....	27
<b>3.9</b> PFPE Micro-chip.....	28
<b>3.10</b> Structure of SIFEL .....	29
<b>3.11</b> SIFEL spin curve.....	30
<b>3.12</b> Membrane Sandwiched between Channels .....	32
<b>3.13</b> CMOS 3-D Architecture.....	33
<b>3.14</b> 3-D Printing of Glass.....	34
<b>3.15</b> SolidScape T66 machine .....	35
<b>3.16</b> Solid Wax Mold.....	35

<b>3.17</b> Wax Molding .....	36
<b>3.18</b> 3-D Wax Geometry .....	37
<b>3.19</b> 3-D Molding of Solvent Resistant Elastomers .....	38
<b>3.20</b> Integration of sensor with a 3-D chip.....	39
<b>3.21</b> Fabrication of Integrated Channels.....	40
<b>3.22</b> Integration of a Filter with Hybrid Molds .....	41
<b>4.1</b> Structure of a Core-Shell Quantum Dot.....	44
<b>4.2</b> Quantum Dot and Dye comparison .....	45
<b>4.3</b> Polystyrene Micro-spheres with Embedded Quantum Dots.....	47
<b>4.4</b> Silica with Quantum Dots.....	48
<b>4.5</b> Cathode-luminescence of Silica Beads.....	48
<b>4.6</b> Cathode-luminescence from core-shell Qdots.....	49
<b>4.7</b> Quantum Dots on Gold Films .....	50
<b>4.8</b> Photoluminescence Spectra .....	51
<b>4.9</b> Time Resolved Measurements of Qdots .....	51
<b>4.10</b> PL decay rate .....	53
<b>4.11</b> Purcell Factor and the Dispersion Curve.....	54
<b>4.12</b> Silicon Dots Passivated with BME.....	55
<b>4.13</b> Hydrodynamic Focusing.....	56
<b>4.14</b> Focus Flow .....	57
<b>4.15</b> Focus Widths with Pressure .....	58
<b>4.16</b> Focus Width Change .....	59
<b>4.17</b> Moving the Focused Stream .....	59
<b>4.18</b> Adjusting Pressure to Move Focus.....	60
<b>4.19</b> Apparatus to Change Pressure.....	61
<b>4.20</b> Quantum Dot Precipitate.....	61
<b>4.21</b> Quantum Dots on surface .....	62
<b>4.22</b> Two Phase Flows .....	63
<b>4.23</b> Thick Line using Two Phase Flows.....	63
<b>4.24</b> Phase Diagram of Air/Liquid Flows .....	64

<b>4.25</b> Pictures of Two Phase Air/Liquid Flows .....	64
<b>4.26</b> 3 Color Lines .....	65
<b>4.27</b> Quantum Dot Mixer .....	66
<b>5.1</b> Light Harvesting Complex of Purple Bacteria .....	68
<b>5.2</b> Spectral Overlap.....	69
<b>5.3</b> Interaction between Dipoles.....	70
<b>5.4</b> Change of Efficiency with Distance .....	71
<b>5.5</b> Molecular Photonic Cascade.....	72
<b>5.6</b> Bi-FRET molecules.....	74
<b>5.7</b> Bi-FRET Fluorescence .....	75
<b>5.8</b> TAMRA Fluorescence in Bi-FRET Molecules .....	76
<b>5.9</b> FTC Fluorescence in Two Colors.....	76
<b>5.10</b> Quad-FRET Molecules.....	78
<b>5.11</b> Quad-FRET Fluorescence.....	79
<b>5.12</b> Cy5 Fluorescence .....	80
<b>6.1</b> Ring Stains by Evaporating Drop.....	83
<b>6.2</b> Lines Forming.....	84
<b>6.3</b> 2-D Geometry of the System .....	85
<b>6.4</b> BSA Molecule .....	85
<b>6.5</b> BSA Pinning Points and Lines.....	86
<b>6.6</b> Breaking of a BSA Line .....	86
<b>6.7</b> Parabolic Fit.....	87
<b>6.8</b> Fluid Flow .....	88
<b>6.9</b> Prong Formation .....	89
<b>6.10</b> “Lollipop” .....	90
<b>6.11</b> SEM images of BSA Lines and Junctions .....	90
<b>6.12</b> Pinning Points of Various Shapes .....	93
<b>6.13</b> Photo-resist Circles and BSA Lines.....	93
<b>6.14</b> Drop Formation.....	94

<b>6.15</b> Line Formation between Two Pinning Points .....	94
<b>6.16</b> Line Growth.....	95
<b>6.17</b> Micro-spheres assemble into Lines.....	96
<b>6.18</b> Smaller Spheres and Smaller Lines .....	96