Functional Nanopatterned Surfaces

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Non-Traditional Lithography and Functional Surfaces

Certain fraction of functionality advantageously located at or near surface of network available for subsequent reactions

Advantages

- No need for complex surface functionalization
- More robust anchoring than SAMs
- Limited substrate effects
- High surface area available for reaction
- Opens synthetically accessible chemistry
Surface Modification

OBJECTIVES:
- Enable the production of functional / reactive surfaces
- Expand the material set to include a variety of reactions
- Demonstrate utility of NCM to make working devices

LONG TERM GOALS:
- Understand and control of all aspects imbedded functionality
- Increase the utility of the technique by expanding the types of functionality

CRITICAL SKILLS & PERSONEL
- Monomer and polymer synthesis and characterization
- Surface chemistry and characterization
- Device assembly and electrical & optical characterization
Tuning the Chemistry and Size of Molded Nanoscopic Features

NCM Patterning of Functional Resins

365 nm light and pressure

Functional Photopolymer Resin

Contact Molding

Brush Growth
Controlled Grafts from Polymeric Surfaces

Embedded Inimer Networks

Embedded inimers; Statistical Percentage at the surface

“Living” RP Growth Process

Top View

Nitroxide LFRP

or

ATRP

Embedded Inimers
**Thickness Change vs Brush Mw**

- Brushes were grown from the surface in the presence of “free” initiator.
- Solution polymer Mw was examined as a measure of brush Mw.
- Excellent agreement between thickness and brush Mw.
Surface Size Control


Controlled Brush Growth From Imprinted Surfaces:
- Demonstrated the ability to mold (imprint) nanostructures and chemically modify surface by unique photopolymer design
- Accomplished by polymer brush growth from patterned resist
- Ability to control and modify size and chemistry of nano-features
Direct Patterning of Porous Dielectrics


- IP Describes direct patterning of porous dielectric layers by imprint lithography
Surface Growth of Light Emitting Polymers

Surface Tethered Polyfluorene Grafts

Surface Tethered Polyfluorene Grafts

“Off” polymer dark
silicon background bright

“On” polymer light
silicon background dark

**Thiophene Polymerization**

Oxidative Polymerization

![Chemical structures and reactions](attachment:image.png)

**GRIM Method**


**Brush Growth**

*via incorporation of thiopheneacetyl-2-oxyethyl methacrylate*
**Brush Growth Results**

**AFM Poly(bromostyrene) Brushes**

Brush Molecular Weight

\[ <M_n> = 34.0 \times 10^3 \text{ g/mol} \]

PDI = 1.27

**Avg. Film Thickness (Ellipsometry, nm)**

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness (nm)</th>
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<tbody>
<tr>
<td>PBrPS Brush</td>
<td>76.43</td>
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<tr>
<td>P3HT Comb</td>
<td>82.48</td>
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**AFM Polythiophene Comb**

- AFM Polythiophene Comb
  - 121.09 nm
Fluorescence Microscopy
GRIM Polythiophene Brushes

Ex. = 330-380 nm
Ex. = 450-490 nm
Ex. = 528-533 nm

Control