`ONTRAFELEN EN STUREN VAN MOLECULAIRE ZELF-ASSEMBLAGE OP SUBSTRATEN'

UNRAVELLING AND GUIDING THE MOLECULAR SELF-ASSEMBLY ON SURFACES

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February 2008

Overview

- Introduction
- Atomic force microscopy
- Experiments and results
 - part I: dendrimer
 - ➡ part 2: macrocycle
- Conclusions and perspectives



Introduction

Nanoscale world



~1.3×10⁷ m

Nanoscale world

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~1.3×10⁷ m >>> ~20 cm

Nanoscale world



 $\sim 1.3 \times 10^7 \,\mathrm{m}$ >>> $\sim 20 \,\mathrm{cm}$ >>> few nm

Molecular self-assembly

Organic molecules as building blocks









second generation polyphenylene dendrimer





second generation polyphenylene dendrimer





HN Yo =

















guiding methods

stamps, molds, patterns, ...

Implementation of self-assembly in existing processes





Atomic Force Microscopy











Experiments and results part I: dendrimer



- In solution
 - critical concentration



• Transfer onto a substrate by dropcasting



• Transfer onto a substrate by dropcasting



Evaporation of solvent

fast



Sum

slow

importance of a (solvent) saturated environment during sample preparation

Optical viewing system

Optical viewing system



Optical viewing system



part I

sample preparation under ambient conditions

➡ fast evaporation



part I

sample preparation under ambient conditions

➡ fast evaporation



part I

sample preparation under ambient conditions

➡ fast evaporation





slow evaporation



part I

sample preparation under ambient conditions

➡ fast evaporation





slow evaporation



• Transfer onto a substrate by dropcasting



Solvent mixtures

adding increasing amount of hexafluorobenzene (C_6F_6) to the dendrimer solution in tetrahydrofuran (THF)



• Transfer onto a substrate by dropcasting



Substrate effect HOPG

silicon



mica





Substrate effect HOPG

silicon



mica



10 µm







Silicon covered with a silane layer as substrate

SiCl₃-(CH₂)11-CN



SiCl₃-(CH₂)₂-(CF₂)₇-CF₃



SiCl₃-(CH₂)₂₁-CH₃

1 *µ*m

SiCl₃-(CH₂)₁₅-CH₃

SiCl₃-(CH₂)₉-CH₃

um



- Solution
 - critical concentration to obtain aggregates
- Fibre formation on substrate
 - saturated environment (slow) / reversible
 - \rightarrow π - π interactions
 - formation on silicon, not on silicon covered with a silane layer







Patterned substrates





SiCl₃-(CH₂)₂-(CF₂)₇-CF₃

Patterned substrates



 $SiCl_3-(CH_2)_2-(CF_2)_7-CF_3$

Patterned substrates



 $SiCl_3-(CH_2)_2-(CF_2)_7-CF_3$











Experiments and results Part 2: macrocycle



- Solution
- Substrate



- Solution
- Substrate







- Solution in a high magnetic field
 - magnets on fridge: 10 gauss = 0.001 tesla
 - experiments: up to 20 tesla (i.e. ×20.000) !













Conclusions and perspectives

- Implementing molecular self-assembly processes in a combined top-down/bottom-up approach could be a route towards creating nanostructures for the design of efficient functional devices in the nanoscale world.
- As these results indicate the potential and challenges of this approach, they open a path for further investigation of other self-assembling systems and combinations with other top-down techniques.

Acknowledgements

- promoters
 - Prof. De Schryver
 - Prof. De Feyter
- Prof. Müllen's group (Max-Planck Institute for Polymer Research)
 - Tianshi Qin
 - Roland Bauer
- Randy de Palma (IMEC)
- Cédric Buron, Prof. Jonas (LLN)
- Jeroen Gielen, Peter Christianen (HFML)

- Prof. Höger's group (Kekulé-Institut für Organische Chemie und Biochemie)
- Prof.Veciana's group (Institut de Ciència de Materials de Barcelona)
 - Núria Crivillers
- Alexander Volodin (Physics department)