Strategies for Controlling Nanoscale Assembly

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Abstract-

I. INTRODUCTION

The bottom–up approach is considered a potential alternative for low cost manufacturing of nanostructured materials [1]. It is based on the concept of self–assembly of nanostructures on a substrate, usually exploiting non-covalent interactions such as e.g. hydrogen bonding and metal organic coordination, or on self-organization in the case of inorganic species. It is emerging as an alternative paradigm for traditional top down fabrication used in the semiconductor industry.

A. Experimental

We demonstrate various strategies to control nanostructure assembly (both organic and inorganic) at the nanoscale. Such strategies focus on exploiting the net balance arising from molecule–molecule versus molecule–surface interactions, and optimizing it to obtain a desired pattern or architecture. A specific approach consists in using long range order reconstructions or the formation of extended patterns as surface cues [2] that guide the spontaneous assembly of atomic and molecular species upon adsorption.

The main characterization tool used to analyze nanopatterned arrays is Scanning Probe Microscopy, both at the solid/liquid interface and under Ultra High Vacuum conditions.

B. Results and Discussion

Depending on the specific material system under investigation, we have developed various approaches, which include, in particular:
(i) Deposition on naturally patterned substrates, which exploit long–range reconstructions such as the adsorption of O_2 on Cu(110) or of N on Cu(001) which form respectively a characteristic nanograting and nanogrid that can be used to control the adsorption of organic molecules [3, 4];
(ii) We are able to control the size and luminescence properties of semiconductor nanostructures, synthesized by reactive laser ablation [5-8]; Si and Ge nanocrystals were formed in a SiO_2 matrix and their size dependent optical properties were investigated.

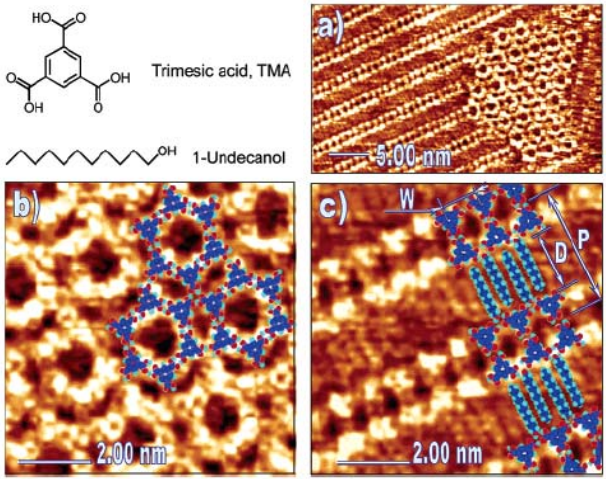

Fig. 1. (a) STM image of SAMNs formed by deposition of 1-undecanol and TMA from heptanoic acid solution on HOPG. (b) TMA flower pattern with molecular model. (c) TMA linear pattern with molecular model.

(iii) We have developed new experimental tools and comparison with simulations are presented to gain atomic scale insight into the surface processes that govern nucleation, growth and assembly at Silicon surfaces [9-12];
(iv) By controlling inter-molecular interactions at the solid/liquid interface on a graphite surface, we demonstrate that it is possible to create specific nanoscale patterns [13-15]; the pattern can be modulated in a controlled manner by changing choice of components. It can also be used as host system to capture guest molecules [16].
(v) We use the Cu(110) surface as a catalyst for the Ullmann coupling reaction to synthesize polyphenylene from di-iodobenzene [17]; the general aim is to develop a new class of materials, namely 2D conjugated polymers [18].
(vi) We developed a simple surface modification strategy for biomaterials which enhances biocompatibility [19-23]. This strategy uses low cost chemical etching using oxidative reagents that create a nanoscale texture on TiO_2 and TiAlV surfaces. We demonstrated that this nanoporous surface can accelerate the growth of osteoblasts while at the same time hindering the growth of fibroblasts, thus presenting a differential/selective signal to different cells.

For papers published in translated journals, first give the English citation, then the original foreign-language citation [6].

C. Conclusions

By exploiting surface cues, surface mediated interactions, intermolecular forces and molecule–surface interactions we demonstrated the formation of long range ordered patterns in a variety of nanoscale systems, which are potentially interesting for a variety of applications in electronics, biomedicine and energy.

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