High resolution imaging of molecular assemblies on a semiconductor surface by non-contact AFM at low temperature

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In this work, we study by non-contact AFM (nc-AFM) the formation of molecular self-assemblies on the passivated surface of boron doped silicon B-Si(111)-(√3x√3)R30° under ultra high-vacuum at low temperature. The investigated molecule is 1-(4'cyanophenyl)-2,5-bis(decyloxy)-4-(4'-iodophenyl)benzene, which possess two aliphatic chains attached to a triphenyl core ended with two different terminations (either iodine or cyano group). The use of a passivated semiconductor enables creating regular and extended structures without significant change in electronic properties of molecules [1, 2].
We perform both scanning tunneling microscopy and nc-AFM imaging using a low-temperature (4K) AFM/STM (JT AFM/STM, SPECS) using high stiffness sensors (Kolibri sensor, k=540kN/m, f_0=1MHz). AFM measurements are carried out in constant "height mode" in which the topography feedback loop is opened and the scanning is achieved while scanning the sensor parallel to the surface plane, and the recorded signal consist in the sensor frequency shift.
The growth of periodic molecular network is observed, formed by parallel lines made by molecule aromatic cores and interdigitated aliphatic chains placed between adjacent rows (Fig.1). In the constant height Δf images we notice submolecular features, obtained without intentional tip functionalization [3], but only by conditioning the tip on the silicon surface. We will discuss the high resolution AFM imaging accompanied by the signal in dissipation channel, as well as the conformation of the molecules in the observed assemblies.

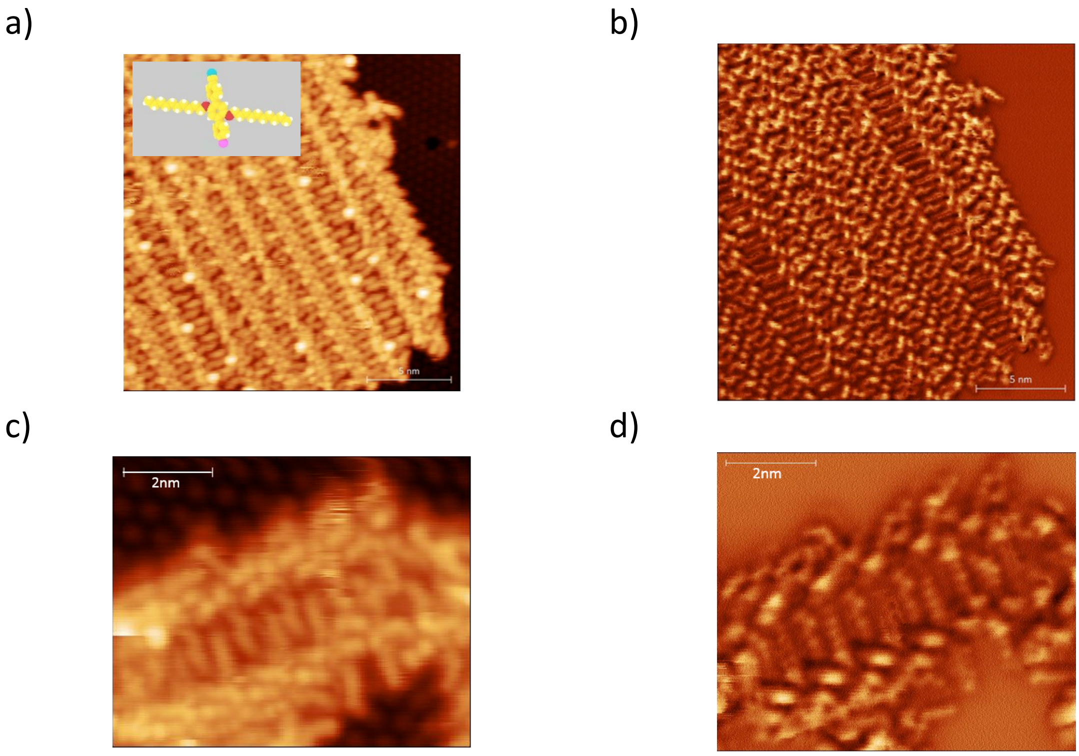

Fig.1 a) STM image of a molecular assembly, V_s=-1.8V, I_t=5pA, model of the molecule in the inset of the image, b) constant height non-contact AFM image of the same zone; c) STM of a small organized domain recorded at V_s=-1.9V and I_t=5pA, d) corresponding AFM image revealing submolecular contrast. All images done with tip oscillation A=50pm.

References:

[1] Makoudi Y,Beyer M, Lamare S, Jeannoutot J, Palmino F, Chérioux F, Nanoscale **2016,** *8*, 12347

[2] Makoudi Y, Jeannoutot J, Palmino F, Chérioux F, Copie G, Krzeminski C, Cleri F, Grandidier B, Surf Sci Rep. **2017**, *72*, 316

[3] Sweetman A, Jarvis S, Rahe P, Champness N, Kantorovich L, Phys. Rev. B **2014**, 90, 165425