

Controlling molecules' momentum with SuMBD: the early stages of Pentacene growth on SiOx/Si

S. Gottardi^{*1,2}, T. Toccoli¹, M. Tonezzer¹, P. Bettotti³, S. Iannotta¹ and P. Rudolf²

1) IMEM-CNR, Istituto Materiali per Elettronica e Magnetismo

Via alla Cascata 56/C I-38123 Povo di Trento, Italy

2) Zernike Institute for Advanced Materials, University of Groningen,

Nijenborgh 4, NL-9747 AG Groningen, The Netherlands

3) Laboratorio nanoscienze, Dipartimento di Fisica, Università di Trento

Via Sommarive 14, I-38050 Povo Trento (Italy)

(*email address: gotto86@gmail.com)

Organic semiconductors are suitable candidates for applications in fields ranging from photonics^[1] to devices and sensors realization^[2]. Good electrical properties, needed for these applications, can be achieved through molecular assembly in a crystalline structure. On the other hand, the feeble nature of the van der Waals forces between the molecules make this goal not easy to reach in organic thin films and the growth process often gives rise to different polymorphs and molecular orientations that strongly limit the final performances. Such limits need to be overcome by a higher control during the growth process. For this reason, the development of methods that permit to role the molecular assembly through the formation of a crystalline structure is of great interest.

Between the vacuum deposition techniques, that up to now give the best results in term of order and purity of the materials, supersonic molecular beam deposition (SuMBD) has shown to improve the control on the growth, giving rise to better morphologies and enhanced electrical properties of the films^[3,4]. Using SuMBD we can easily tune the kinetic energy, momentum and internal energy of the impinging molecules^[5] influencing the molecules assembly, the island formation and coalescence^[6]. The precursor state of the molecule is also important for the activation of new pathways for the adsorption of the molecules on the surface. The possibility to control the different energetic parameters of the impinging molecules and understand how they can influence the molecular assembling is of great importance for the realization of high performances devices.

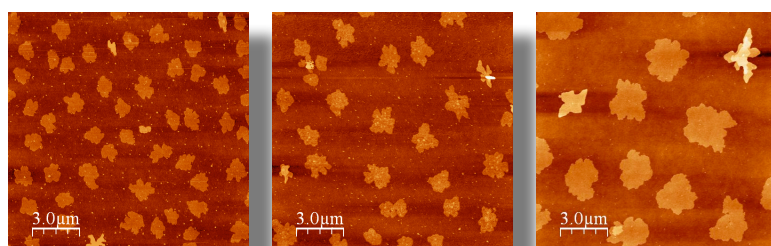


Figure 1: AFM micrographs of Pentacene sub-monolayer growth using SuMBD. From the left, the results for 0°, 45°, 75° of beam incidence angle are reported. The energy of the impinging molecules was about 7eV.

We report a systematic atomic force microscopy study of Pentacene sub-monolayer morphologies on SiO_x/Si (60° contact angle), resulting from depositions at room temperature, in different growth conditions. During these early stages of growth, we found that the kinetic energy and the momentum of the impinging molecules play a key role in determining the monolayer morphology. In particular, we investigate the effects induced by changing the parallel and perpendicular momentum of the molecules arriving on the surface. Variations in the energy relaxation mechanisms involving the two component of the momentum activate different adsorption processes leading to modified island fractal dimension, island density and sticking coefficient. The parallel momentum favours a longer mean free path of the molecules adsorbed on the surface giving the possibility for a better assembly and surface energy minimization. Instead, the perpendicular momentum can be fundamental for the activation of deeper adsorption sites on the surface. Our measures show a progressive lowering of the island density when increasing the component of the molecules' momentum parallel to the surface (k_{\parallel}) with the formation of more compact (less fractal) islands, better for the realization of ordered films (Figure1). Large single crystal domains are formed, which is a key aspect for increasing the devices performances.

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