10th International Conference on Molecular Electronics
November 29 - December 2, 2021

Building UniMolecular Scaffolding for Electronic Devices

Enrique Escorihuela,[1,2] Alberto Concellón,[3] Iván Marín,[4] Varshini J. Kumar,[5] Lucía Herrer,[1,2,6] Paul J. Low,[5] Pilar Cea,[1,2,6] José Luis Serrano,[1,4] Santiago Martín[1,2,6]

[1] *Instituto de Nanociencia y Materiales de Aragón (INMA), CSIC-Universidad de Zaragoza, Zaragoza 50009, Spain. smartins@unizar.es*
[2] *Departamento de Química Física, Universidad de Zaragoza, 50009, Zaragoza, Spain.*
[3] *Department of Chemistry, Massachusetts Institute of Technology, Cambridge, MA 02139, USA.*
[4] *Departamento de Química Orgánica, Universidad de Zaragoza, 50009, Zaragoza, Spain.*
[5] *School of Molecular Sciences, University of Western Australia, Crawley, WA, 6009, Australia.*
[6] *Laboratorio de Microscopias Avanzadas (LMA). Universidad de Zaragoza, 50018, Zaragoza, Spain.*

Abstract:

It is well known that many properties of advanced materials are related with a well-organized internal structure.[1-2] In this context, the construction of the next generation of electronic and optical devices will require a spatial orientation and control of the molecular arrangement of the functional molecules.[3] Although unimolecular electronics are already a reality, these are not consistent between themselves and to control the precise geometry at the molecule–metal contacts is one of the long-standing challenges in single-molecule electronics.[4] Therefore, to fabricate multiple unimolecular devices in a parallel way is still a remaining challenge.[5] Here, a controllable, tuneable, versatile and integral layer-by-layer (LbL) strategy to build a large-scale unimolecular scaffolding in a parallel way has been developed. This strategy consists in combining successive self-assembly layers of a substituted metallic porphyrin and a functional molecule, which is located in a defined position strictly normal to the substrate, spaced out from each other and keeping a 1:1 stoichiometric ratio through an 'electrical' contact (Figure 1). This strategy allows to modulate the structure of the final scaffolding by varying the functional molecule depending on the searched application; that is, extending this strategy to the preparation of more complex large-scale unimolecular devices. Thus, we hope this innovative layer by layer strategy offers new nanotechnological applications, since offer several exciting potential advantages, including suppression of in-plane transport, access for a wide range of functional wires, or free volume for electromechanically operated switches.

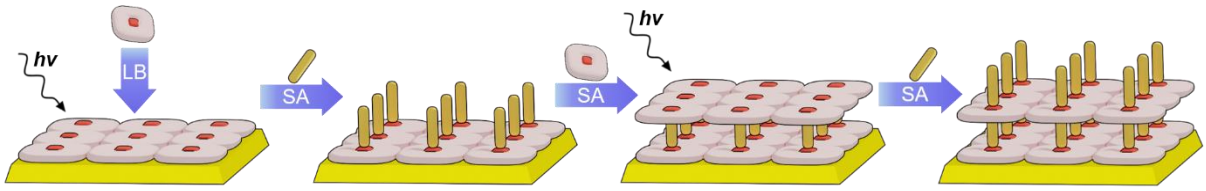

Figure 1. Scheme of the strategy followed to build layer by layer a large-area unimolecular scaffolding device.

References:

1. Xu, C. P.; Puente-Santiago, A. R.; Rodriguez-Padron, D.; Munoz-Batista, M. J.; Ahsan, M. A.; Noveron, J. C.; Luque, R., Nature-Inspired Hierarchical Materials for Sensing and Energy Storage Applications. Chem. Soc. Rev. 2021, 50, 4856-4871.
2. Santos, P. J.; Gabrys, P. A.; Zornberg, L. Z.; Lee, M. S.; Macfarlane, R. J., Macroscopic Materials Assembled from Nanoparticle Superlattices. Nature 2021, 591, 586-591.
3. Su, T. A.; Neupane, M.; Steigerwald, M. L.; Venkataraman, L.; Nuckolls, C., Chemical Principles of Single-Molecule Electronics. Nat. Rev. Mater. 2016, 1, 16002.
4. Sun, L.; Diaz-Fernandez, Y. A.; Gschneidtner, T. A.; Westerlund, F.; Lara-Avila, S.; Moth-Poulsen, K., Single-Molecule Electronics: From Chemical Design to Functional Devices. Chem. Soc. Rev. 2014, 43, 7378-7411.
5. Vilan, A.; Aswal, D.; Cahen, D., Large-Area, Ensemble Molecular Electronics: Motivation and Challenges. Chem. Rev. 2017, 117, 4248-4286.