

Superlattices of ultra-long graphene nanoribbons by on-surface synthesis

Cesar Moreno¹

Mirco Panighel¹, M. Vilas², E. Guitián², D. Pérez², Bernhard Kretz³, A. Garcia-Lekue³, D. Peña², Gustavo Ceballos¹, Aitor Mugarza^{1,4}

¹ Catalan Institute of Nanoscience and Nanotechnology (ICN2), CSIC and The Barcelona Institute of Science and Technology, Campus UAB, Bellaterra, 08193 Barcelona, Spain

² Centro Singular de Investigación en Química Biolóxica y Materiais Moleculares, C/ J. de la Fuente, Campus Vida, U. de Santiago de Compostela, 15782 Santiago de Compostela (Spain)

³ Donostia International Physics Center, Paseo M. de Lardizabal 4, 20018 San Sebastian (Spain)

⁴ ICREA – Institució Catalana de Recerca i Estudis Avançats, Lluís Companys 23, 08010 Barcelona, Spain

cesar.moreno@icn2.cat

One of the biggest advantage of the on-surface synthesis of graphene nanoribbons (GNR)[1] with respect to other top-down approaches lies on the capability to synthesize atomically precise GNRs with complex shape and edge structure [2]. The formidable effort made over recent years in developing a great variety of GNRs is however weakened by a lack of the control of their length and long-range order. Both requirements should be addressed for a successful implementation of GNRs in high performance nanoelectronic and nanophotonic devices [2,3].

In this work, we report the synthesis and the structural, electrical and chemical characterization of periodically modulated armchair graphene nanoribbons. By using the home-designed precursor (Fig. 1-left) on Au(111), we obtain GNRs with the width is modulated by alternating pairs of 7 and 13 carbon atom chains (Fig.1). An unconventional surface reconstruction-guided growth leads to ultra-long (~100 nm),

parallel GNRs that can even cross monoatomic steps. Spectroscopic measurements reveal an energy gap of 1.2 eV, i.e., very close to that of 13-AGNR [4]. Spatial mapping of the valence and conduction bands shows intensity modulations along the GNR that indicate that the periodically alternating width act as an intra-ribbon superlattice for delocalized electrons.

As we increase the coverage GNRs align in periodic arrays that are only limited in size by the domain size of the underneath herringbone reconstruction (Fig.1-right). This arrangement constitutes an interesting example of inter-ribbon superlattice that can be exploited for tuning the plasmonic response [3].

References

- [1] Cai, J. et al., Nature (2010).
- [2] L. Talirz et al., Adv. Mat. (2016)
- [3] I. Silveiro et al. New J. Phys. (2015)
- [4] Y.C. Chen et al. ACS Nano (2013)

Figures

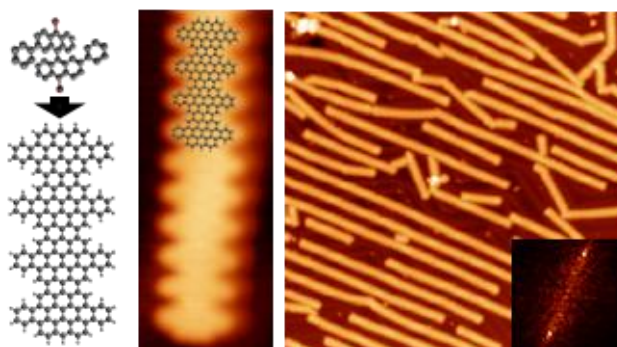


Fig. 1: (Left) Sketch of the organic precursor and the GNR obtained. (Center) Topographic STM image (3x8 nm²) displaying the 7-3 edge. (c) STM topography (80x80 nm²) showing a high density of individual GNRs in a parallel arrangement with a periodic distance of ~3.9nm between them.