101° congresso della Società Italiana di Fisica

Electronic structure of adsorbed organic precursor toward graphene nanoribbons

Avvisati Giulia

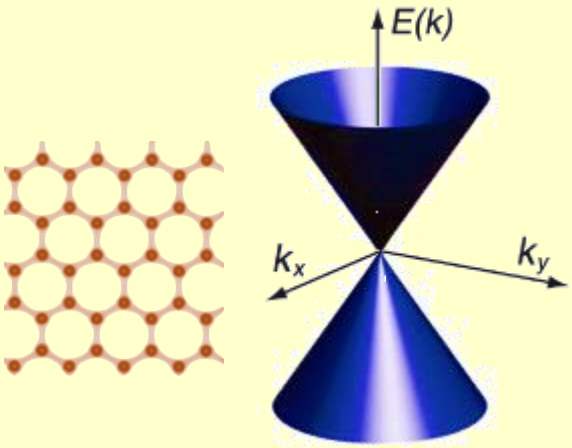
Della Pia A., Ourdjini O., Massimi L., Mariani C., Betti M.G.

Graphene nanoribbons

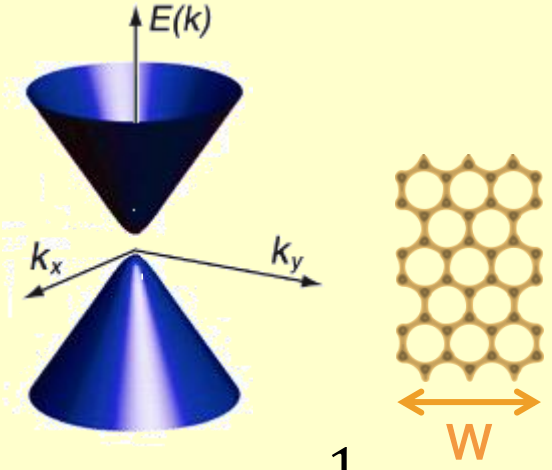
- Why quantum confinement?

Berger C. et al., Science 312, 1191-1196 (2006)
Geim A.K. et al., Nature Mat. 6, 183-191 (2007)
Raza H. et al., Phys.Rev.B 77, 245434 (2008)

from semimetallic



to tunable band-gap semiconductor



$$k_T = \frac{n\pi}{W}$$

$$\Delta E = \Delta E(W) \propto \frac{1}{W}$$

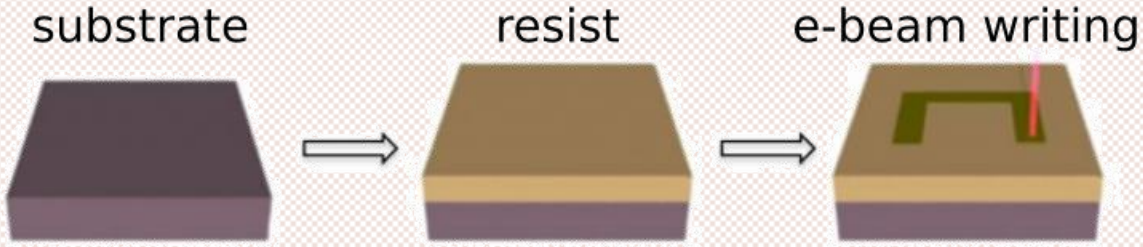
- Ambipolar transport
  - High mobility

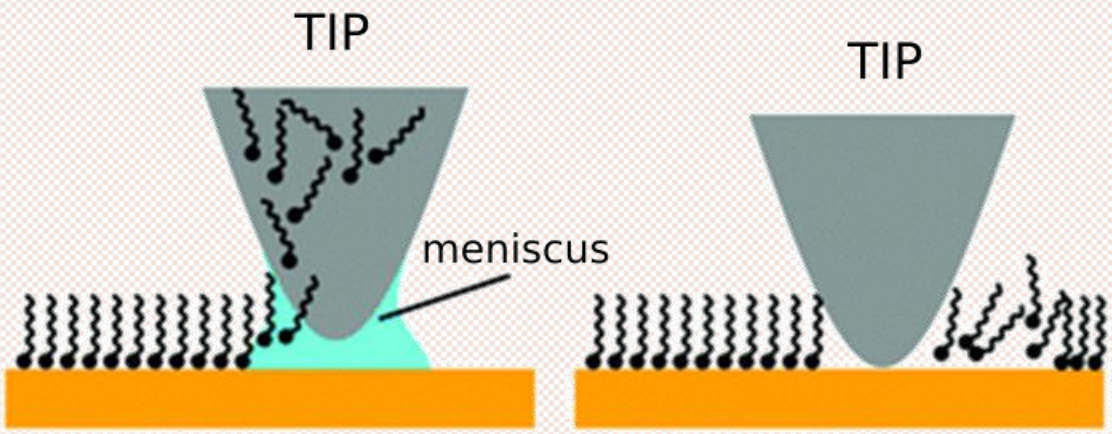
Graphene nanoribbons: lithography

- How to obtain quantum confinement?

Top-down lithographic approaches

Han M. et al., Phys.Rev.Lett. 98, 206805 (2007)
Giesbers A.J.M. et al., Sol.Stat.Comm. 147, 366-369 (2008)
Tapaszto L. et al., Nature Nanotech. 3, 397-401 (2008)





✓ Cheap

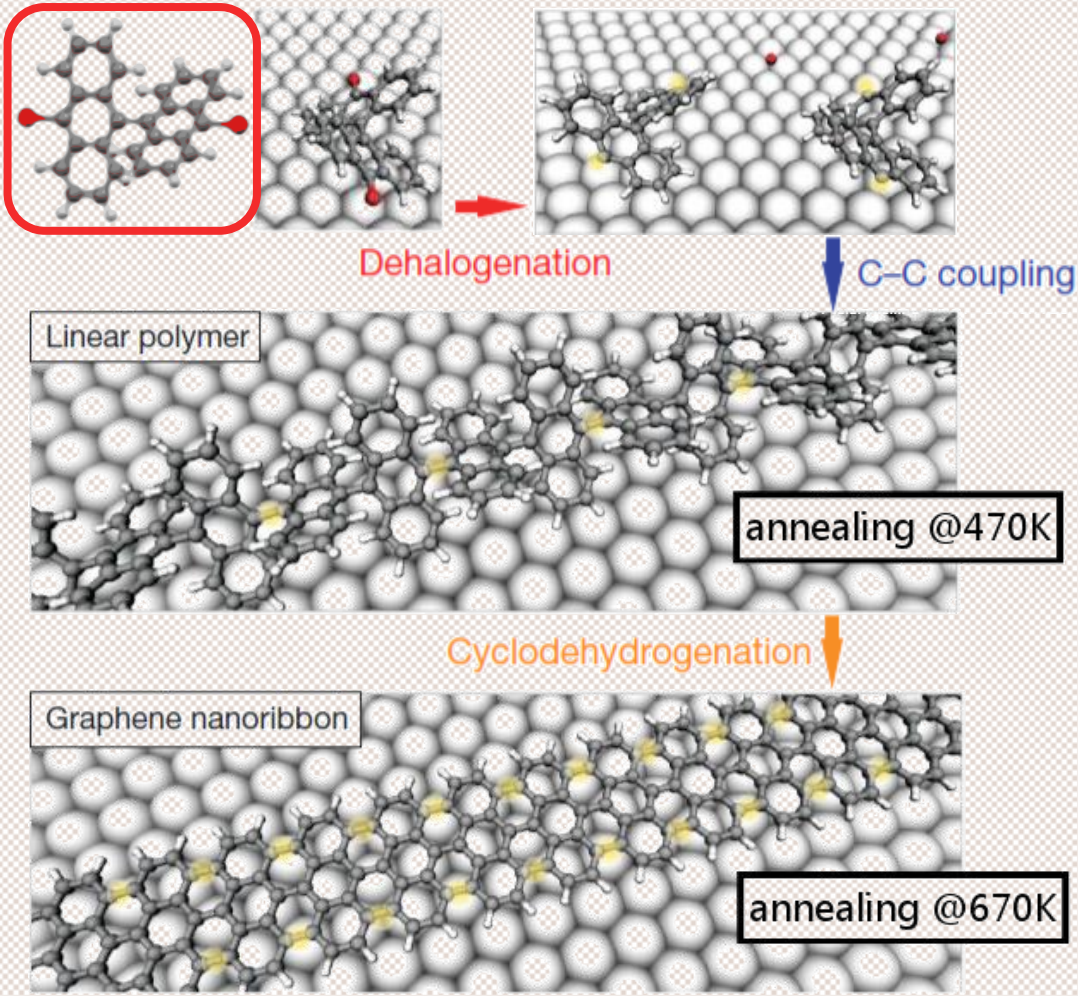
✓ GNR with different shapes and width

X Too wide (>10 nm) GNR

X Rough edges

Graphene nanoribbons: molecular precursor

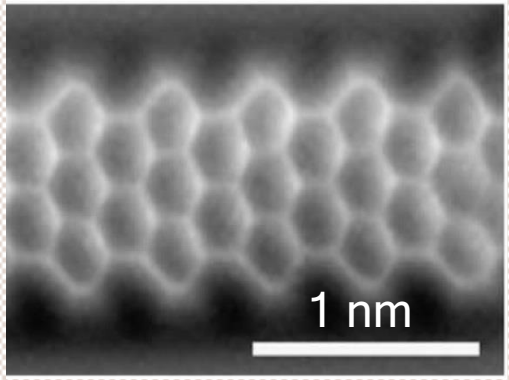
Bottom-up approach



Key ingredients:

- Molecular precursor
- Catalytic substrate

✓ **Atomic precision!**



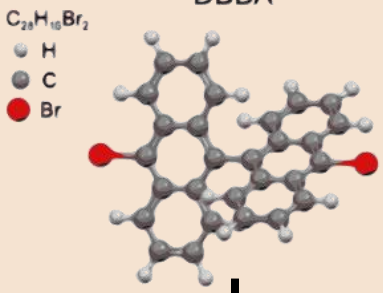
Cai J. et al., Nature 466, 470-473 (2010)
van der Lit J. et al., Nature Comm. 4, 2023 (2013)

Our choice: DBBA/Au(110)

Massimi L. et al., J.Phys.Chem. C 119, 2427-2437 (2015)

RT deposition

10,10'-dibromo-9,9' bianthracene
DBBA

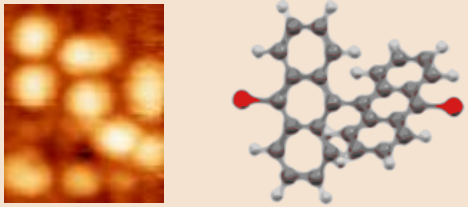


HT (470K) deposition

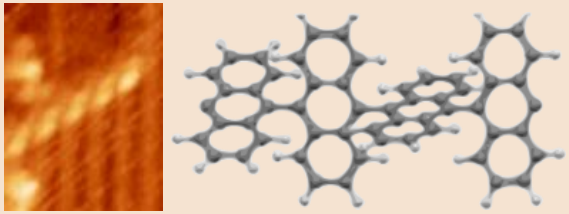
Temperature

Coverage

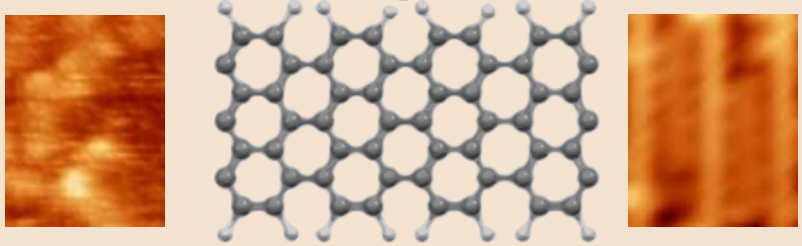
300K, intact molecule



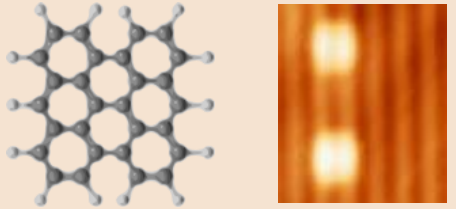
400K, polyanthryl



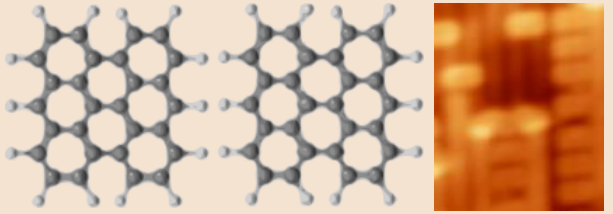
700K, GNR



0.1 SL, bisanthene



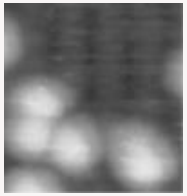
0.5 SL, bisanthene chains



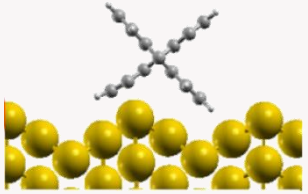
1.0 SL, GNR

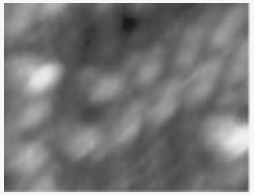
Electronic properties: from DBBA to GNR

Chemical species involved in the process of GNR formation:

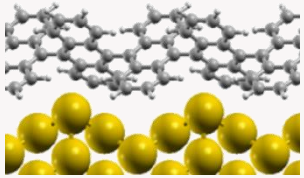


- DBBA molecule

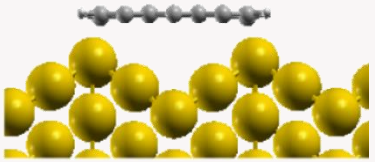




- polyanthryl

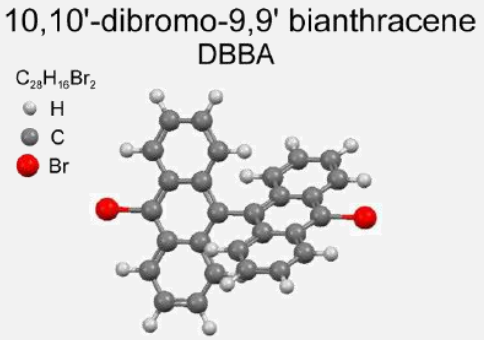


- nanoribbon

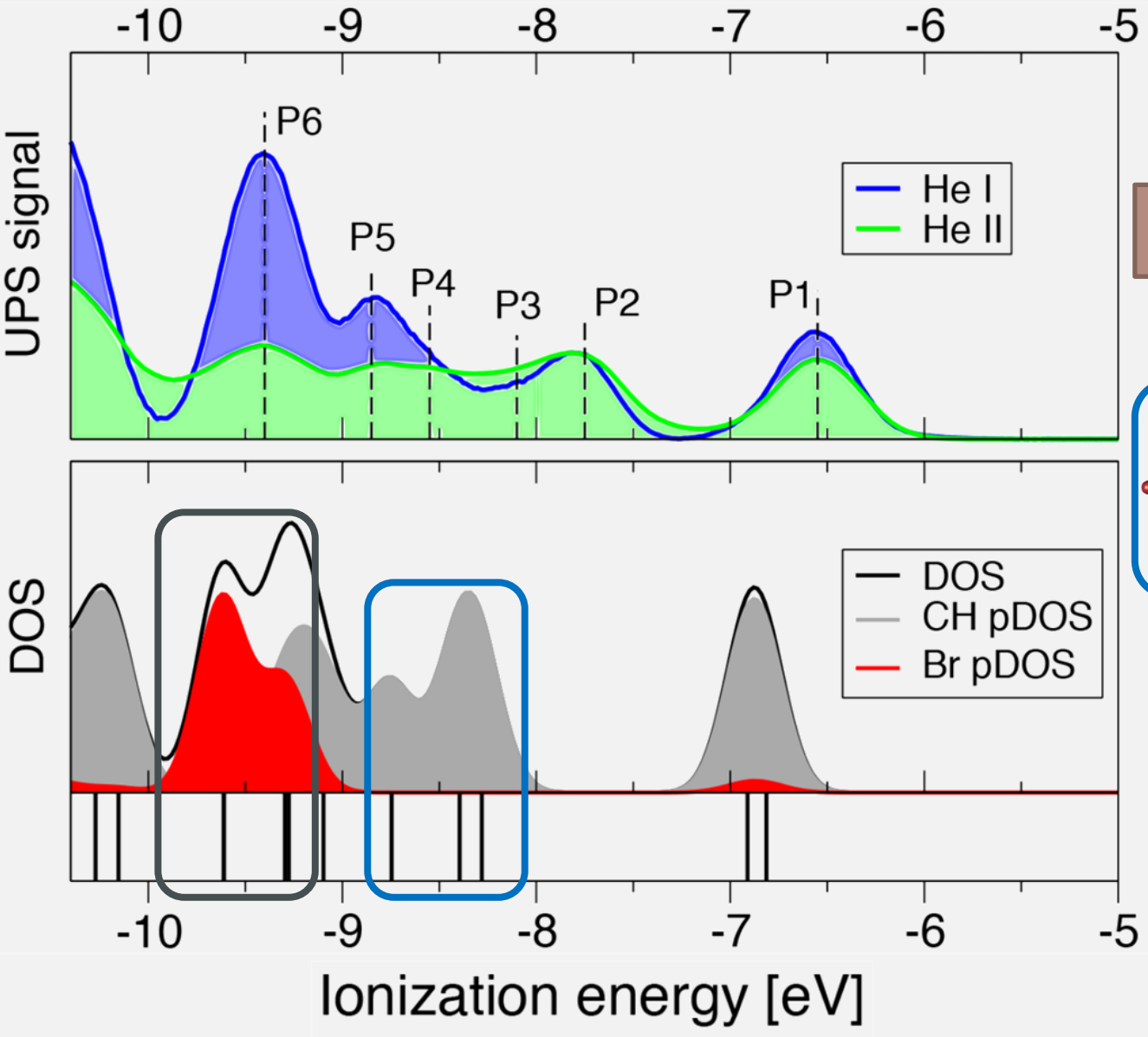


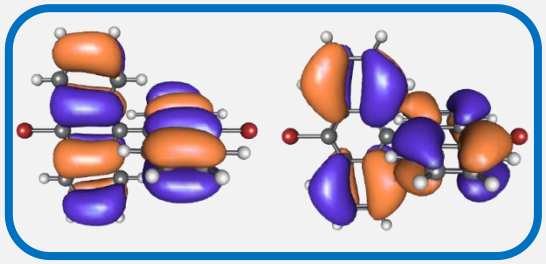
Massimi L. et al., J.Phys.Chem. C 119, 2427-2437 (2015)
Della Pia A. et al., to be published

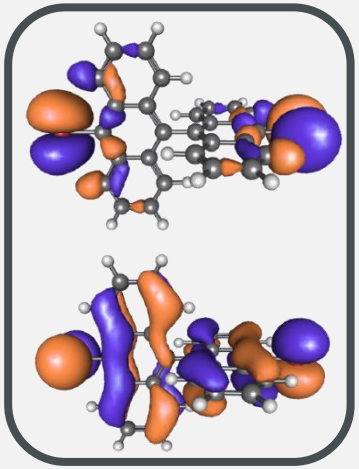
Our molecular precursor: DBBA



Della Pia A. et al., to be published

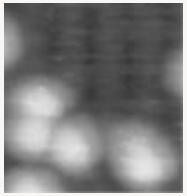


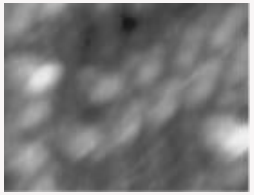




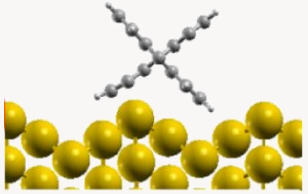
Electronic properties: from DBBA to GNR

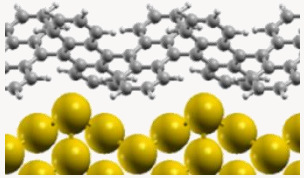
Chemical species involved in the process of GNR formation:

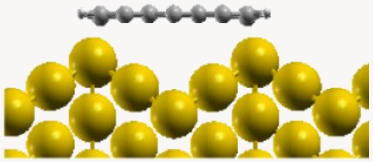




- DBBA molecule
- polyanthryl
- nanoribbon



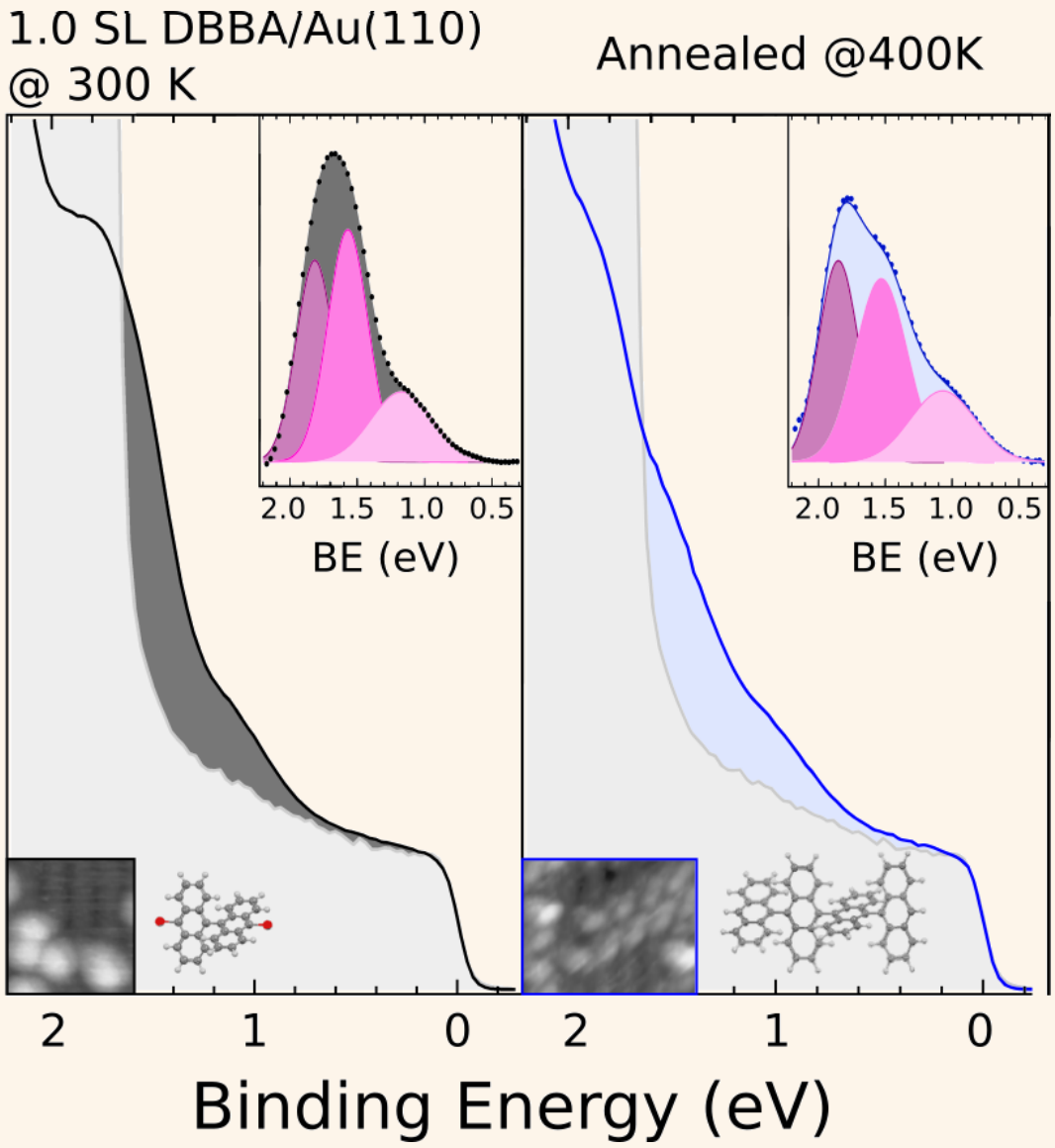




Massimi L. et al., J.Phys.Chem. C 119, 2427-2437 (2015)
Della Pia A. et al., to be published

Evolution of the VB spectrum

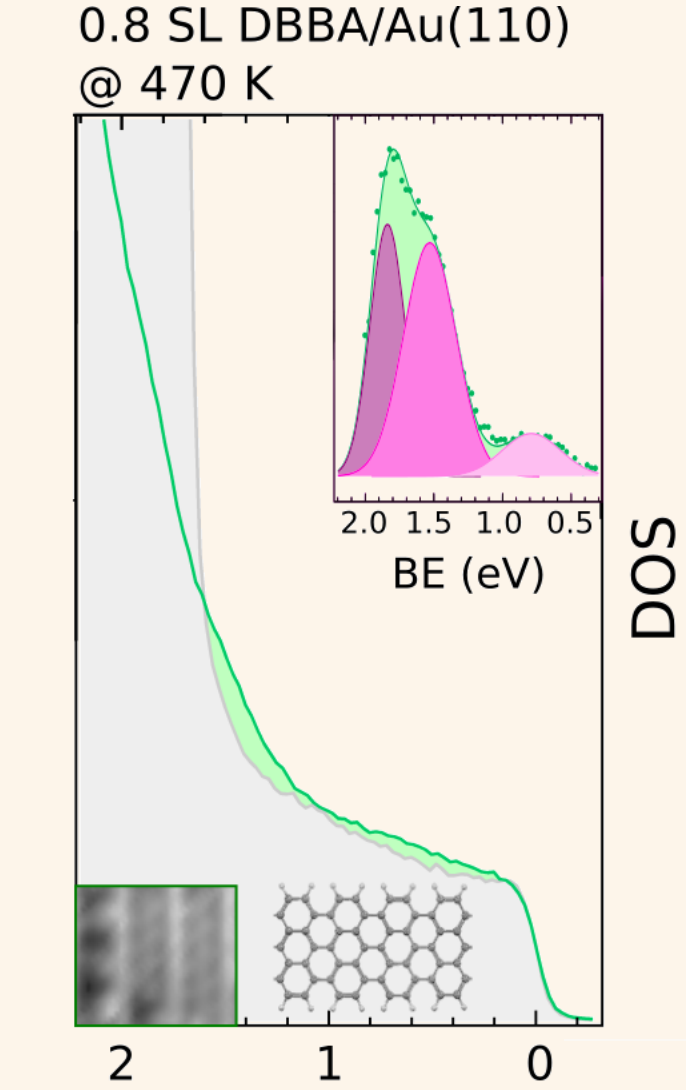
Della Pia A. et al., to be published

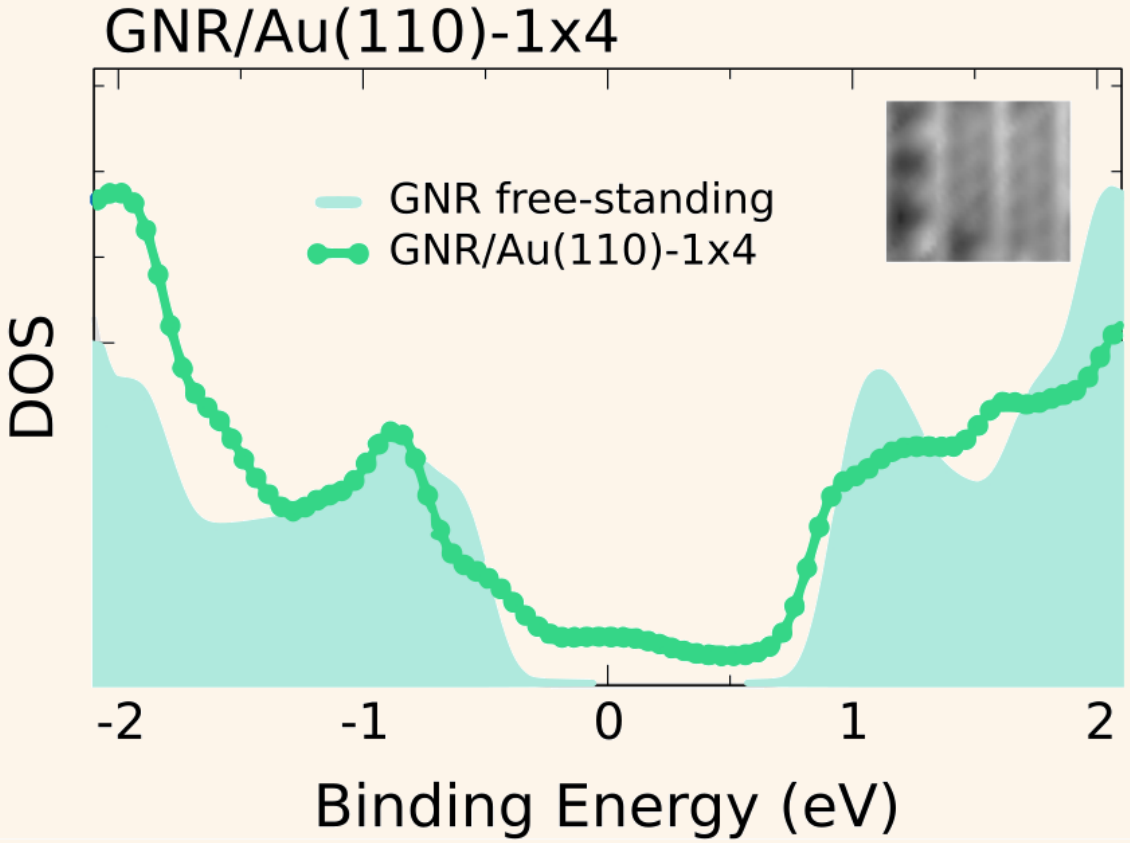


Sample	C-Au peak BE (± 0.05 eV)
DBBA	1.15
Polyanthryl	1.05

Evolution of the VB spectrum

Della Pia A. et al., to be published





Conclusions

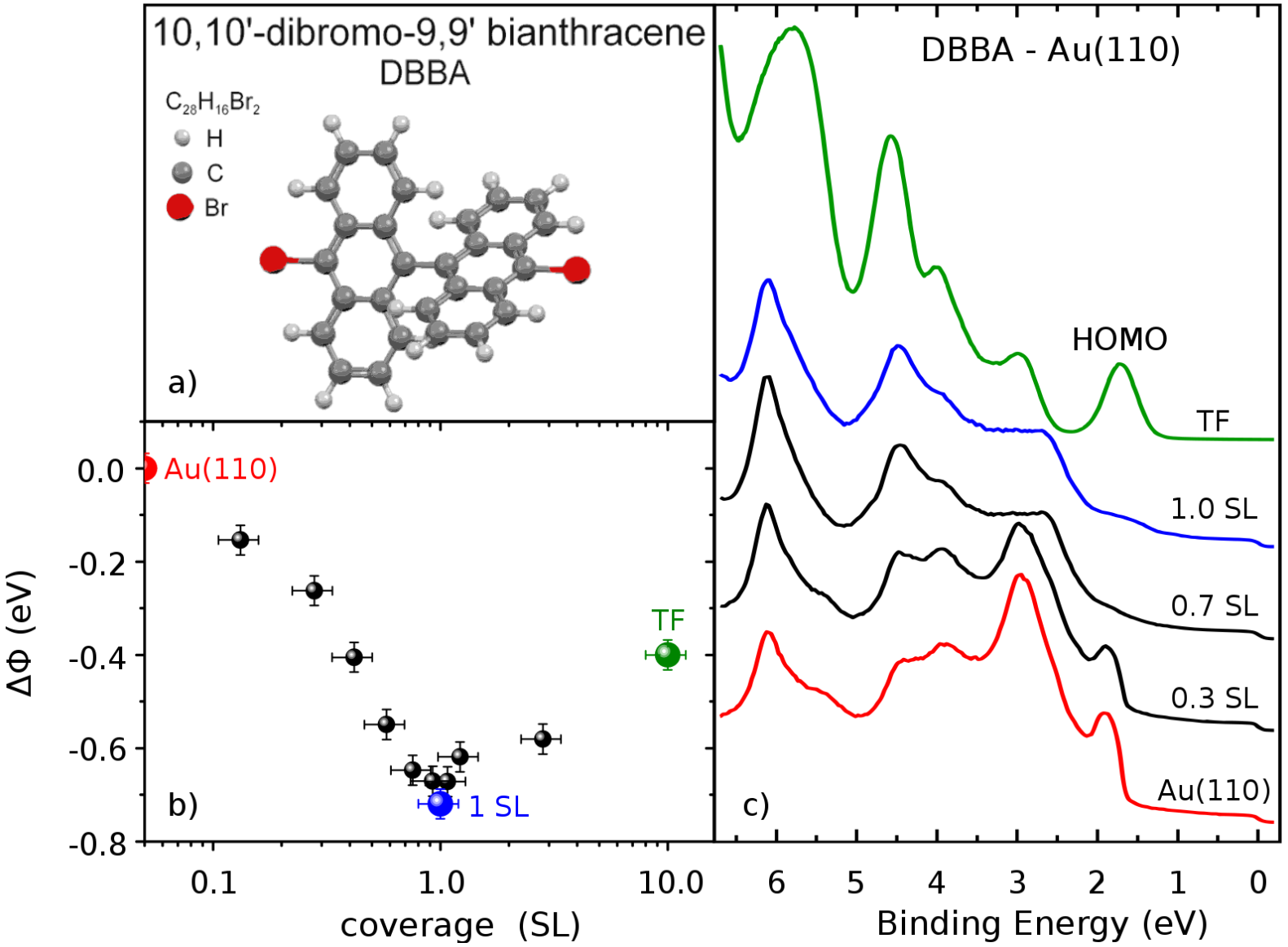
- Identification and attribution of the molecular electronic states;
- Study of the DBBA/Au(110) interaction;

Sample	C-Au peak BE (± 0.05 eV)
DBBA	1.15
Polyanthryl	1.05

- Determination of the valence band evolution

	Free-standing state BE (± 0.05 eV)	Interaction state BE (± 0.05 eV)
GNR	1.50	0.80

Electronic state evolution



Au(110) vs Au(111)

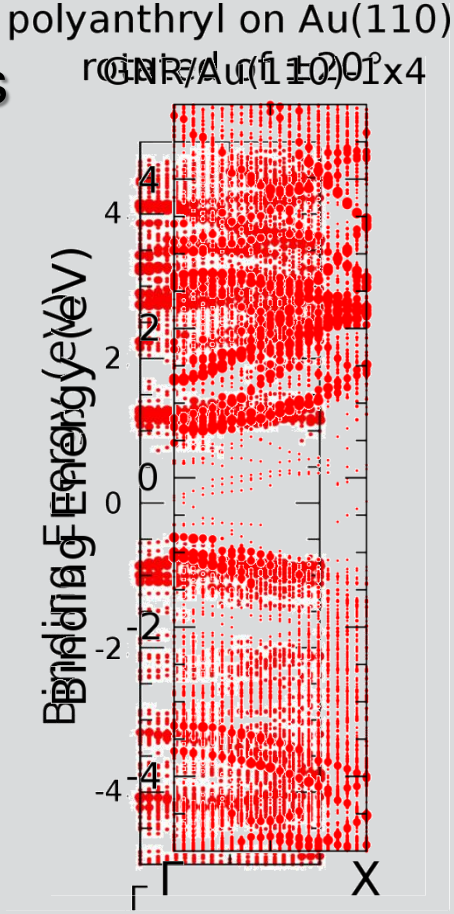
Chemical species

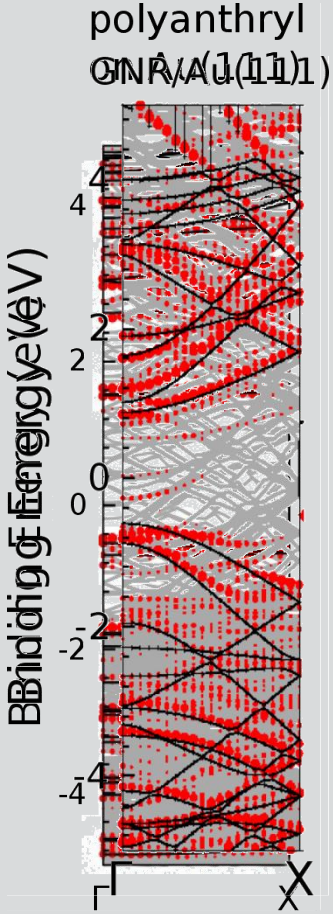
DBBA

Polyanthryl

Bisanthene

Nanoribbons





Chemical species

DBBA

Polyanthryl

Nanoribbons

Batra A. et al., SI Chem. Sci. 5, 4419-4423 (2014)
Massimi L. et al., J.Phys.Chem. C 119, 2427-2437 (2015)
Della Pia A., to be published

Batra A. et al., Chem. Sci. 5, 4419-4423 (2014)
Ruffieux P. et al., ACSnano 6, 6930-6935 (2012)
Bronner C. et al., J.Chem.Phys. 140, 024701 (2014)