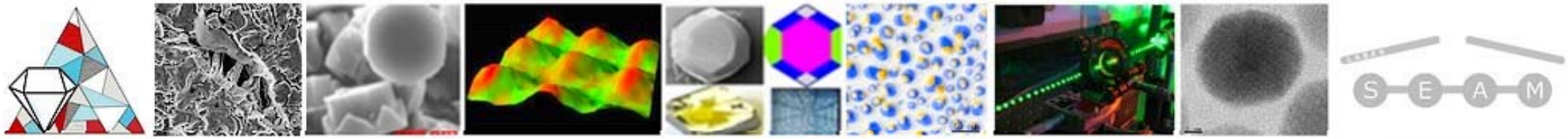
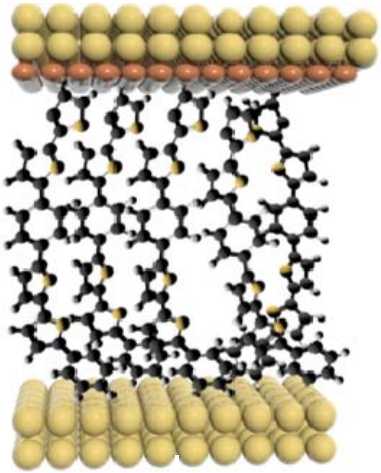


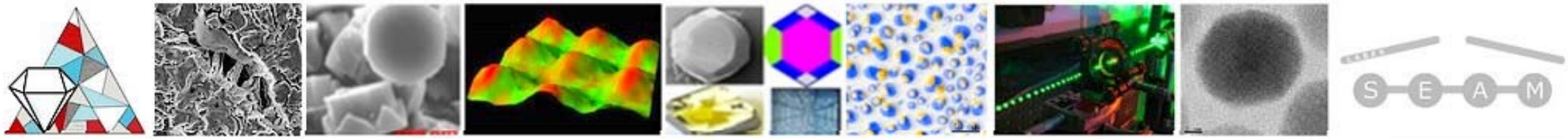
LABEX SEAM

Multi-terminal architecture in molecular junctions: towards electrical and optical gating



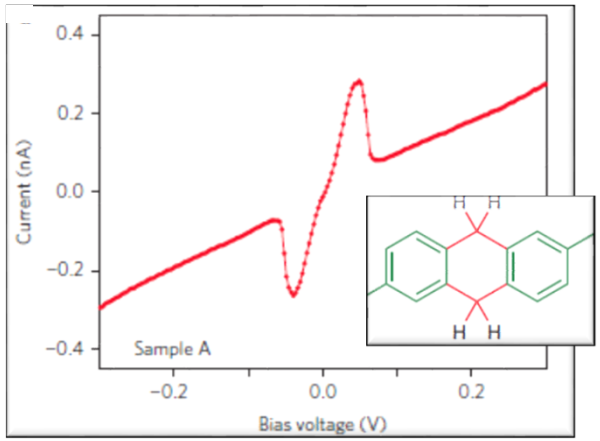
M.L. Della Rocca, C. Barraud, P. Lafarge (TELEM)
P. Martin, J.-C. Lacroix (NEC)

Hired 1 year post-doc: Kevin Dalla Francesca



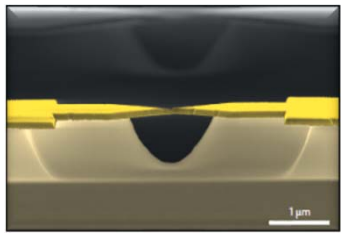
LABEX SEAM

Molecular electronics: few recent works

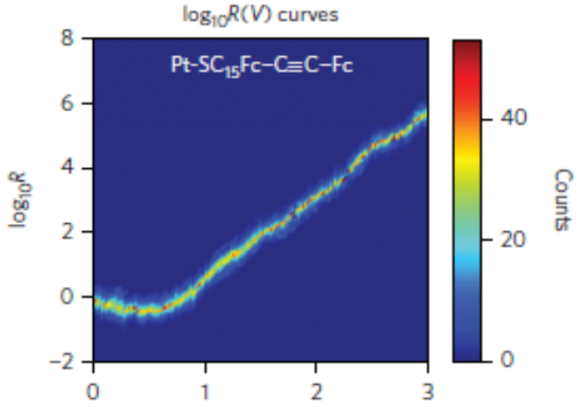


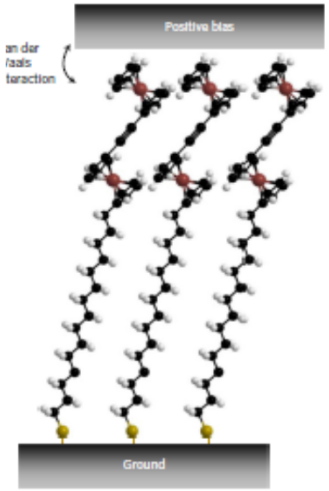
Negative differential conductance

Perrin et al.,
Nature Nanotech. 9, 830 (2014)



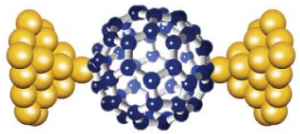
Rectification

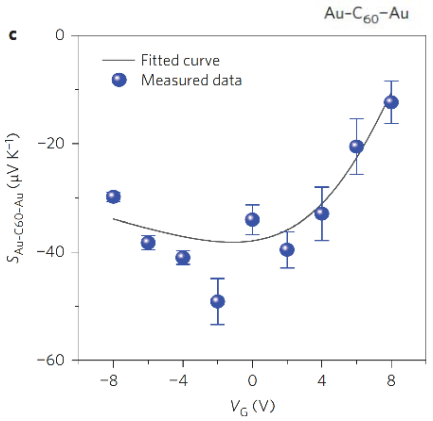


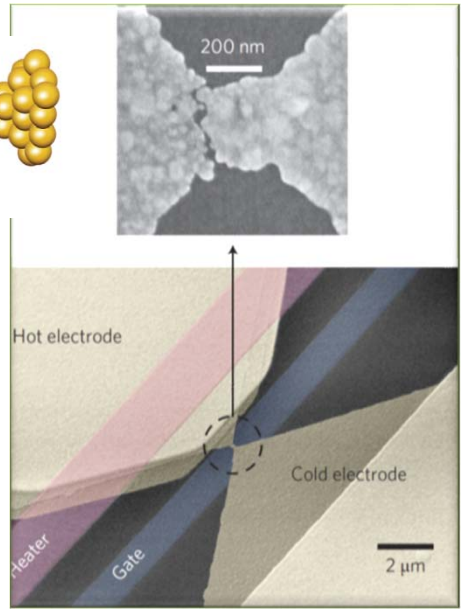


Chen et al., Nature Nanotech. 12, 797 (2017)

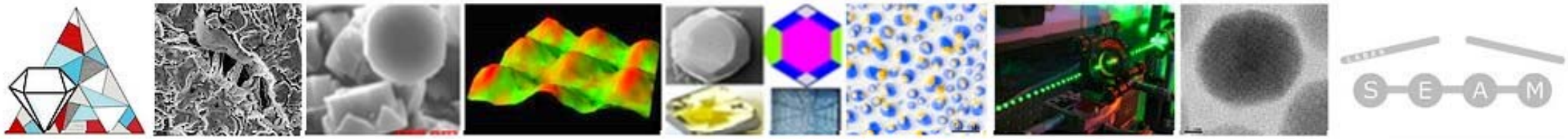
Thermoelectricity





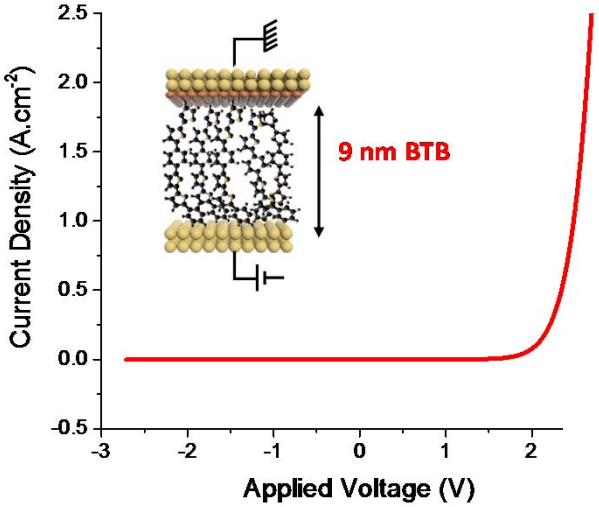


Kim et al., Nature Nanotech. 9, 881 (2014)



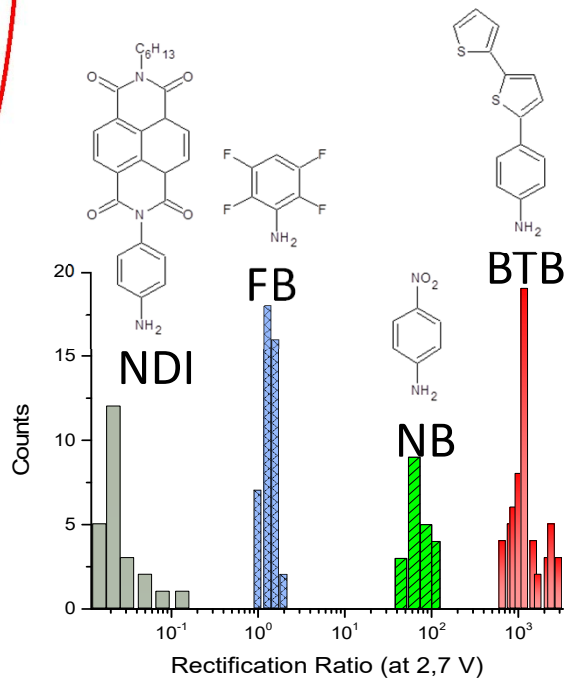
LABEX SEAM

Large area molecular junctions

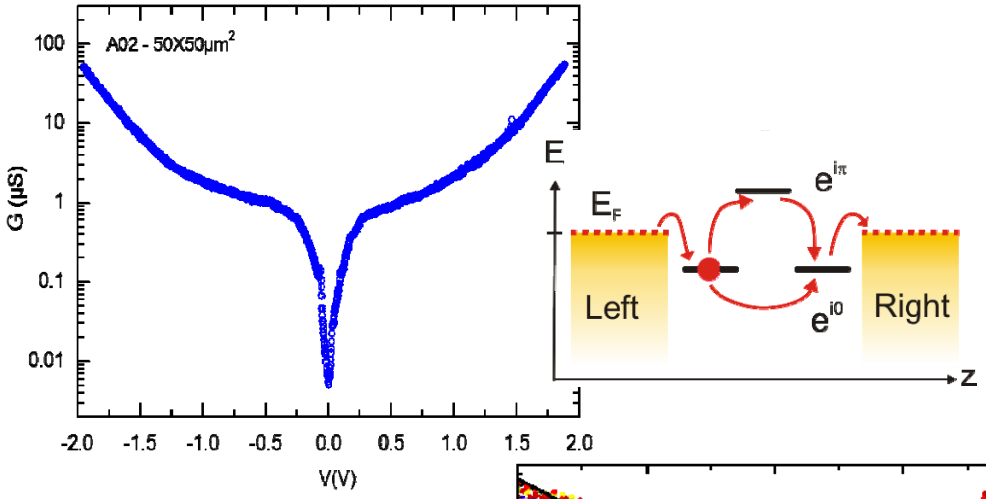


Van Nguyen et al.,
JACS **139**, 11913 (2017)
Martin et al.,
JACS **134**, 154 (2012)

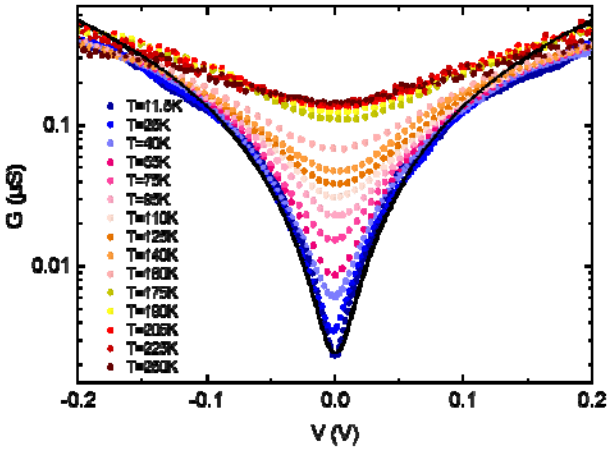
Rectification



Quantum Interference

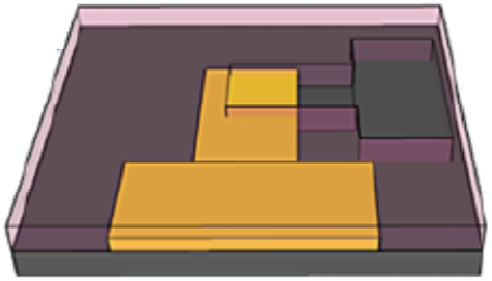


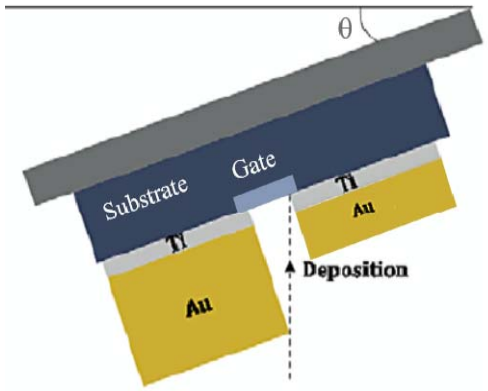
Rabache et al.,
JACS **135**, 10218 (2013)
Bessis et al.,
Sci. Rep. **6**, 20899 (2016)
Salhani et al.,
PRB **95**, 165431 (2017)



What about gating of large area junctions?

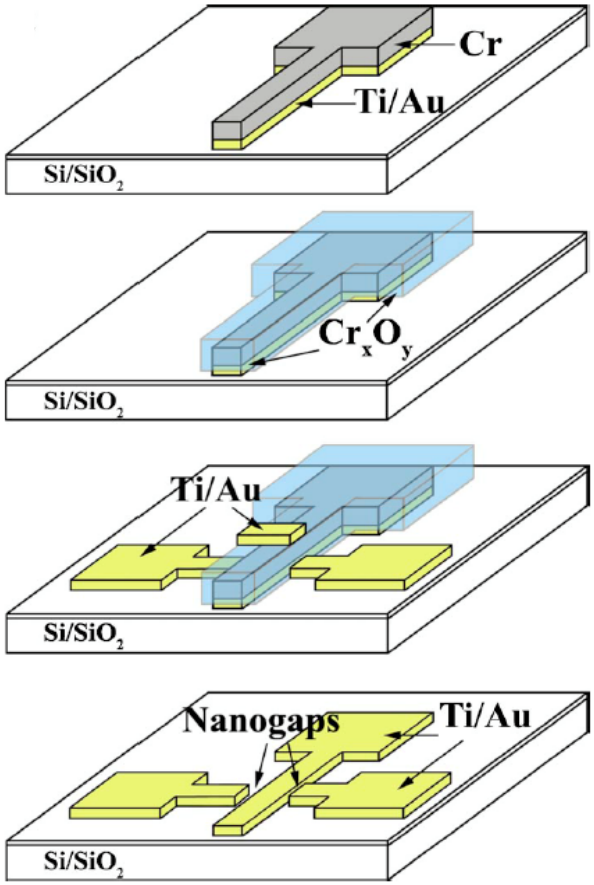
Horizontal architecture: high aspect ratio nantrenches





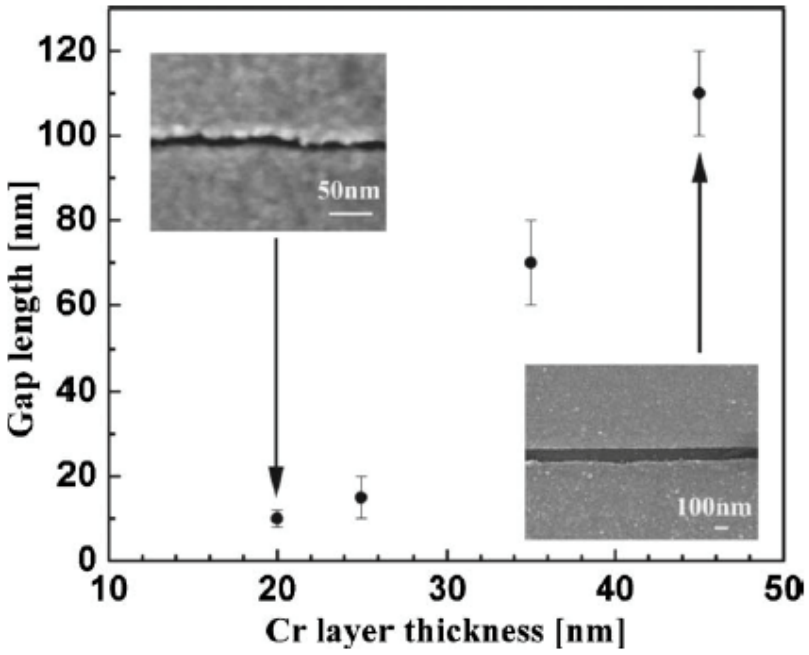
Dayen et al., Nanotechnology **21**, 335303 (2010)

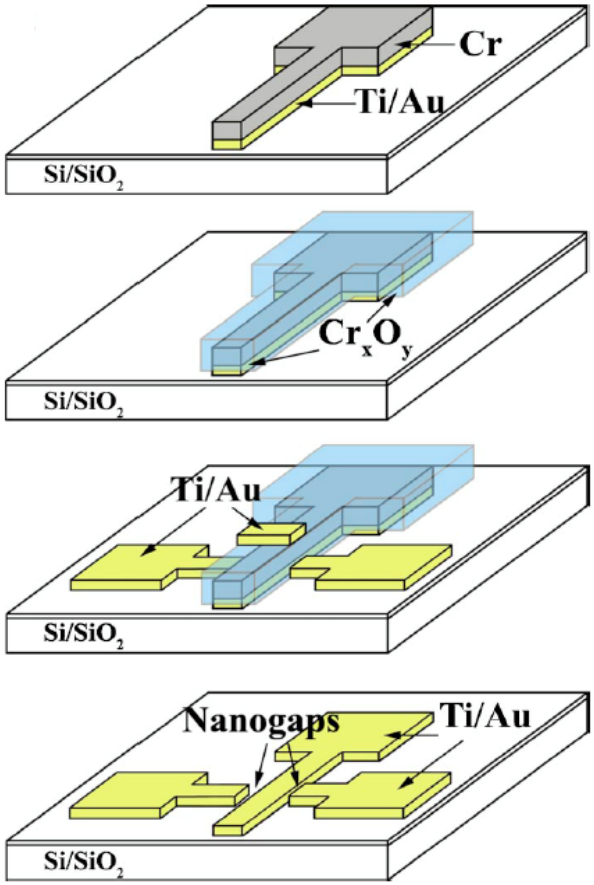
Fabrication of high aspect ratio nanotrenches (~10^4)



Fursina et al., APL **92**, 113102 (2008)

Horizontal architecture: high aspect ratio nantrenches



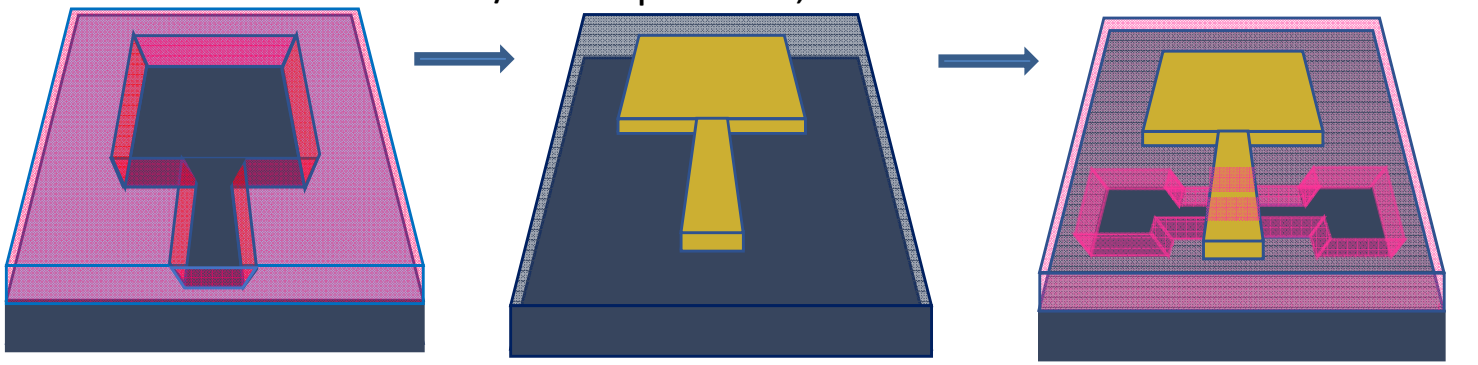


Fursina et al., APL 92, 113102 (2008)

Edge mediated shadow evaporation method

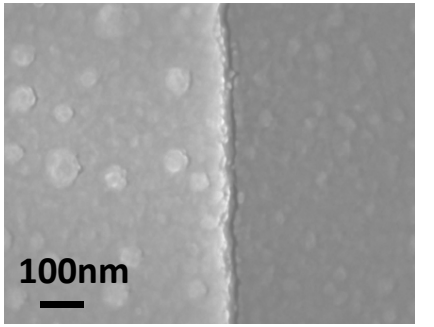
e-beam lithography for thinnest edges

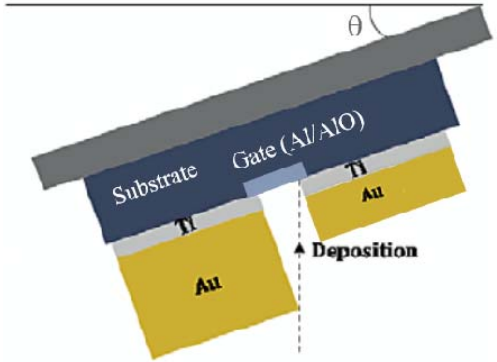
Ti/Au evaporation, d~50 nm

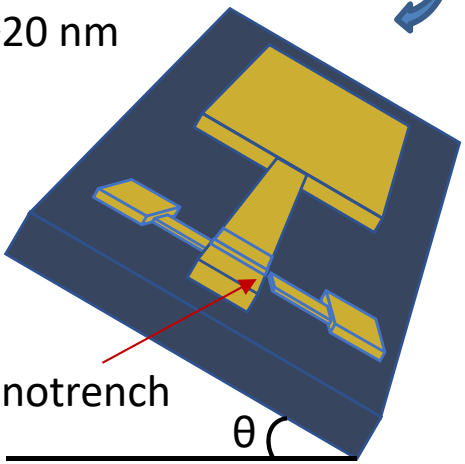


optical lithography

Ti/Au shadow evaporation, d~20 nm



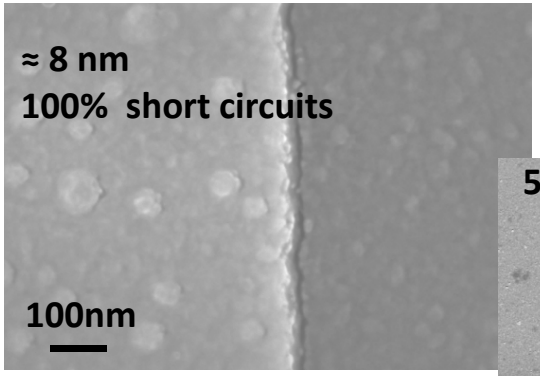




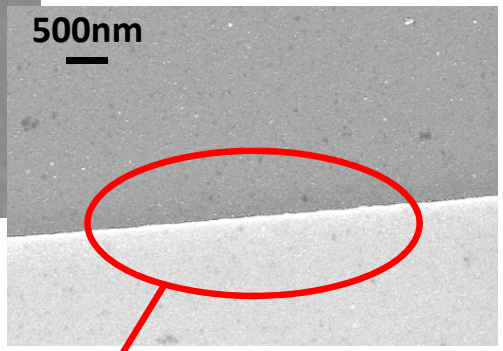
Electrografting of the molecular layer
as last step of the molecular junction fabrication

Optimization of the deposition angle

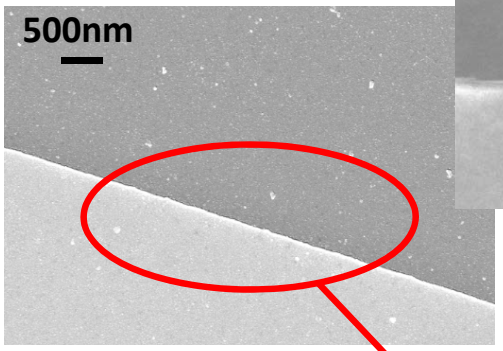
θ=35°



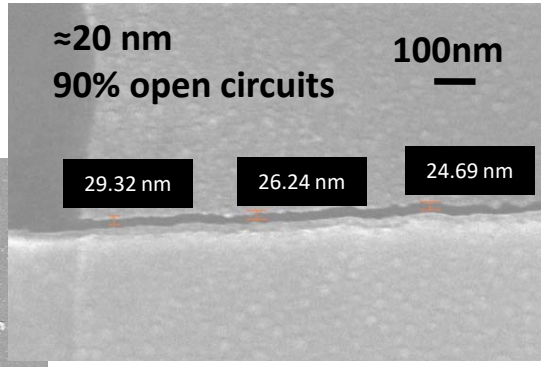
θ=38°

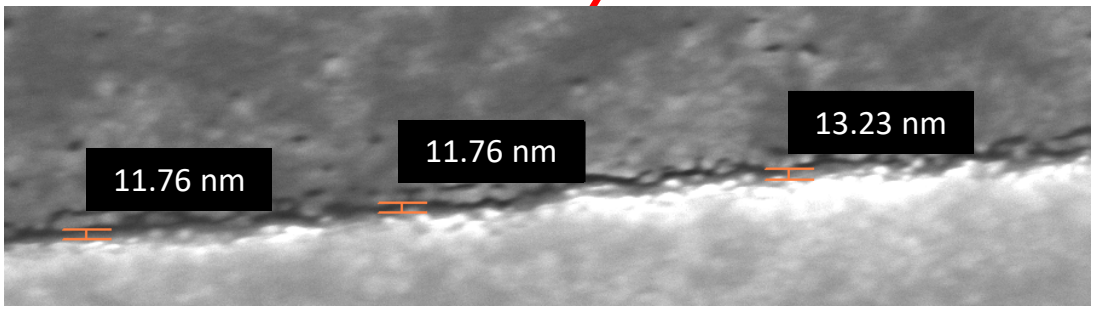


θ=40°

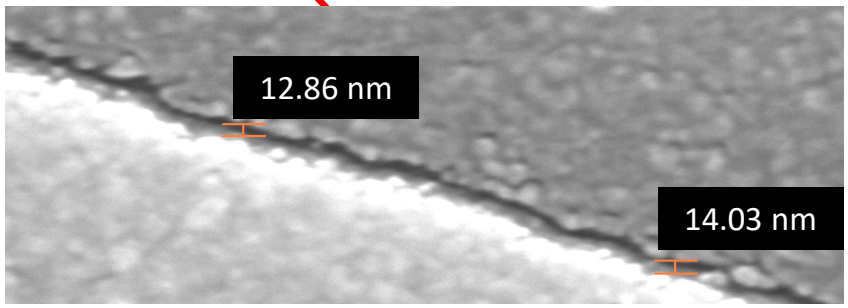


θ=45°



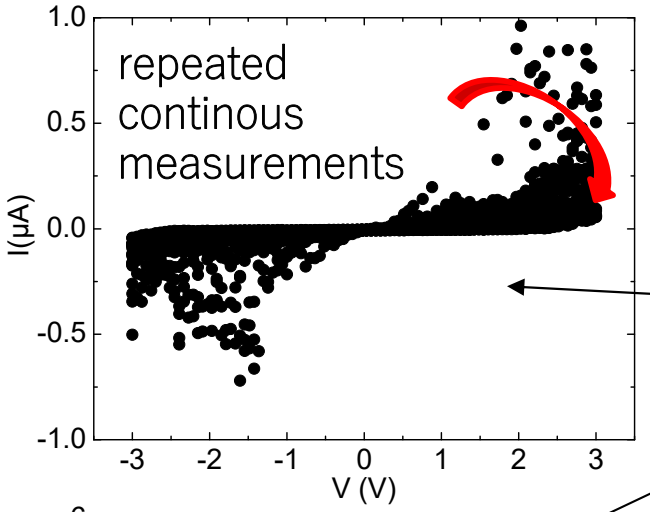


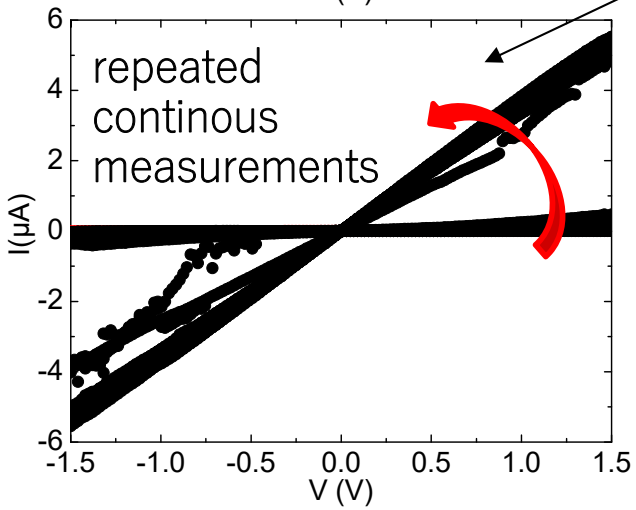
Nanotrenches width ~10 -15 nm, 33% open circuits



Nanotrenches width ~12-17 nm, 75% open circuits

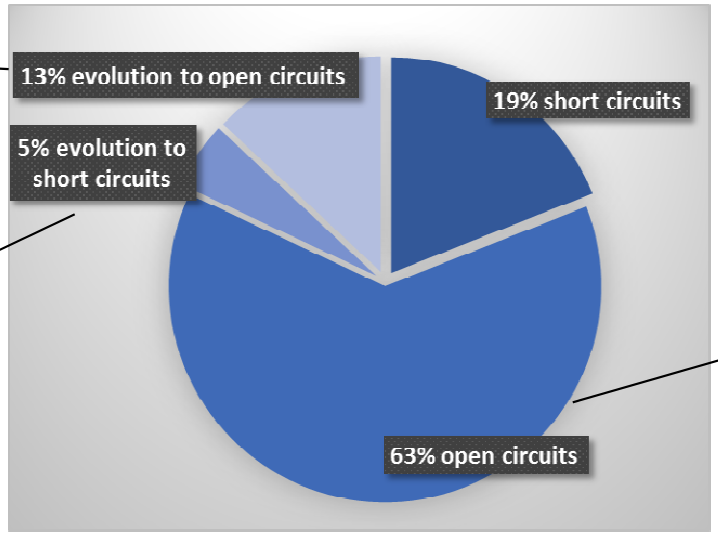
Electrical characterization of non-grafted nanotrenches

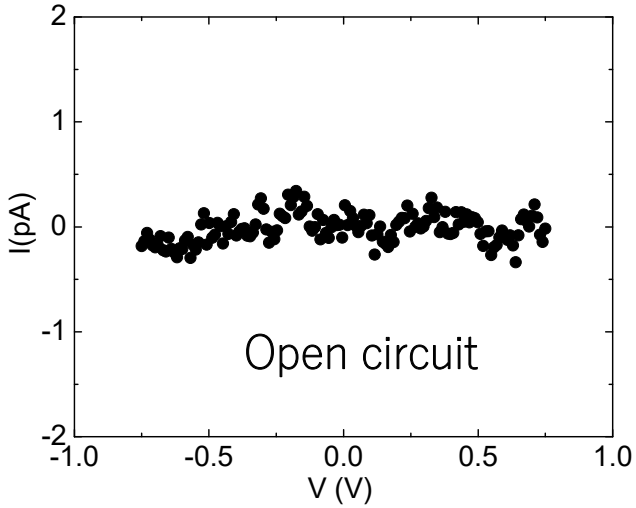




Evaporation angle θ=40°

I(V) curves of 120 nanotranches, T_{amb}



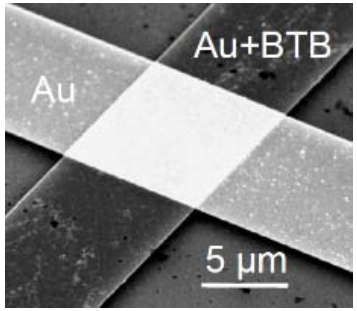


Necessary to electrically measure the devices before inserting the molecules!

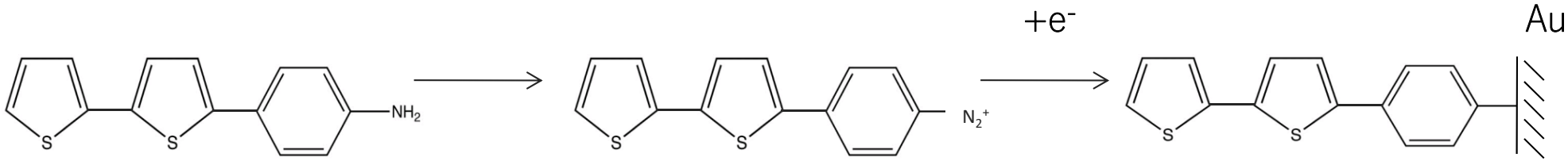
Molecular layer electrografting (Itodys)

Métal (Au, C, PPF)/ molécule (FL, BP, NBP, NAB, AB)/ métal (Au, Cu, C)

Anariba et al., J. Phys. Chem. B 109, 11163 (2005)
Bonifas and R.L. McCreery, Nature Nanotech., 5, 612 (2010)
Choi et al., Science 320, 1482 (2008)
Bergren et al., Phys. Chem 114, 15806 (2010)



Electroreduction of diazionium salts



BTAB precurseur

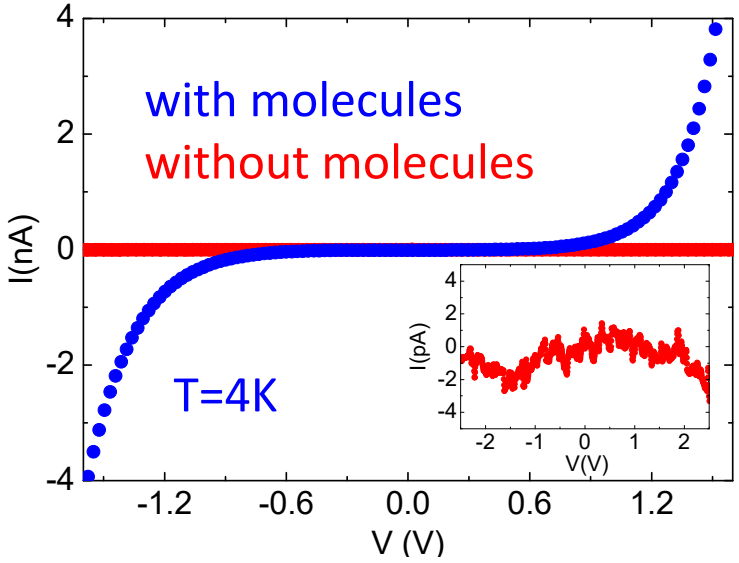
1-(2-bisthienyl)-4-aminobenzene

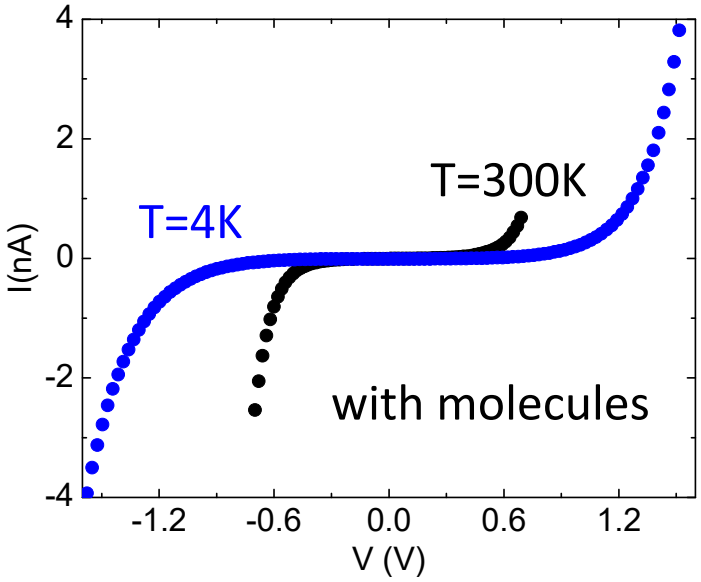
in $NaNO_2$, $HClO_4$, NBu_4BF_4

BTB

Electrical characterization of grafted nanotrenches

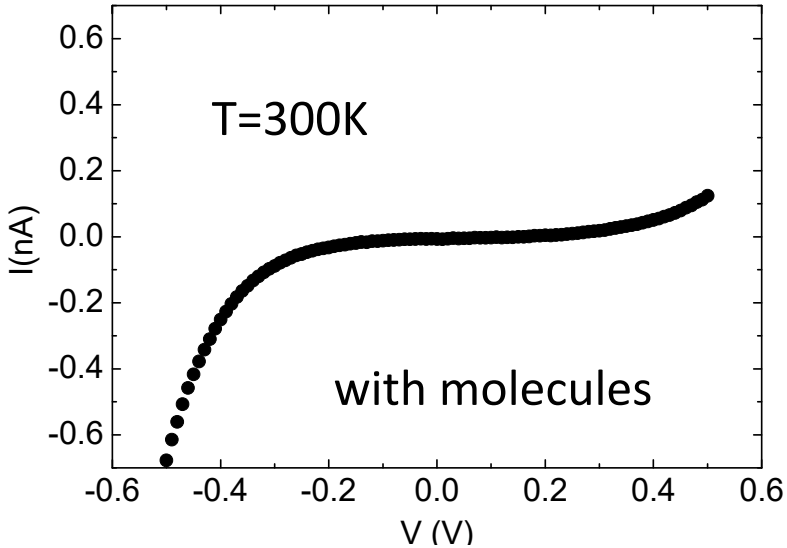
Anthraquinone (AQ), nominal thickness ~ 15 nm ⟹ comparable to nanotrench width

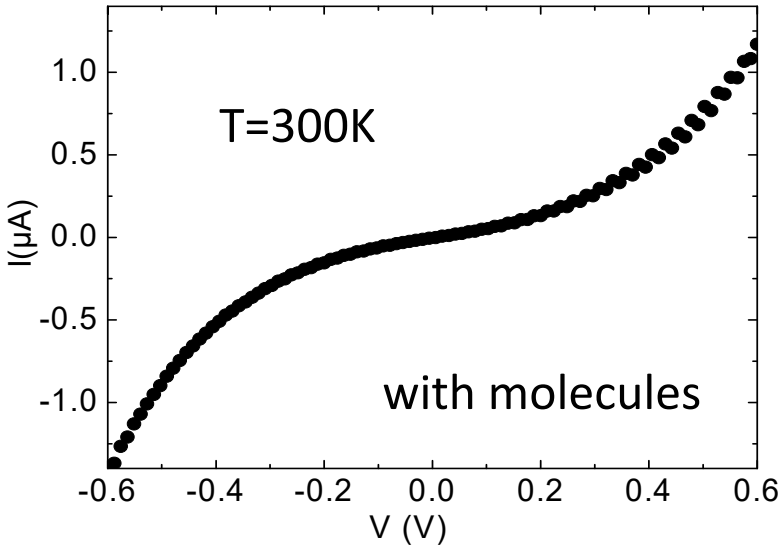




Electrical characterization of grafted nanotrenches

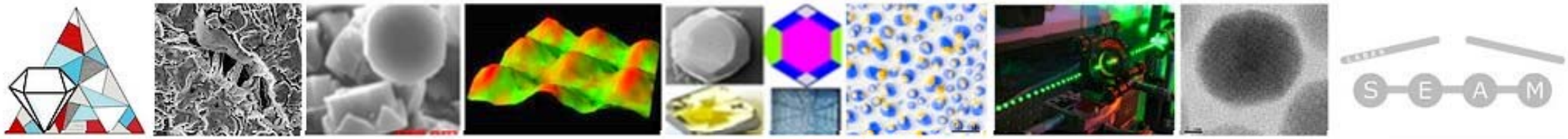
Anthraquinone (AQ), nominal thickness ~ 15 nm ⟶ comparable to nanotrench width





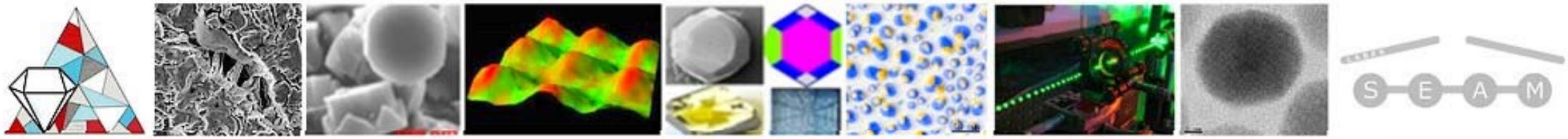
For a grafted AQ thickness of ~ 5 nm (< to nanotrench width) ⟶ totality of open circuits

Better control molecular contact area?



Work in progress:

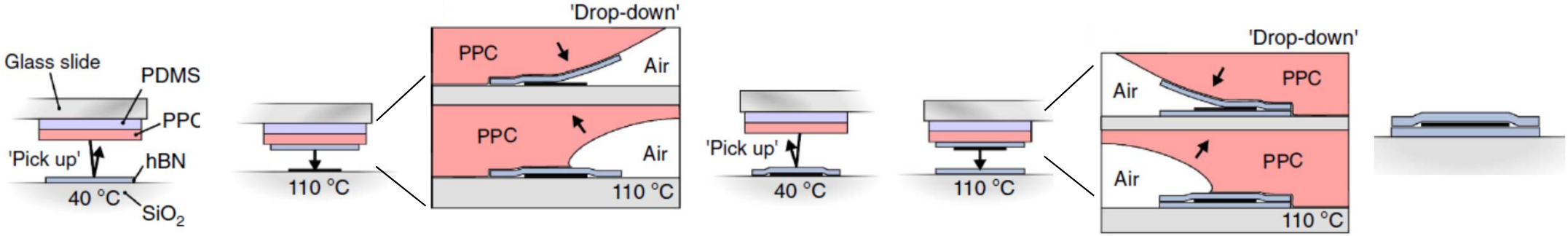
- ✓ More statistics on electrical characterization before and after grafting at low T
- ✓ AFM analysis of grafting
- ✓ Insertion of local top gate
- ✓ Optical gating



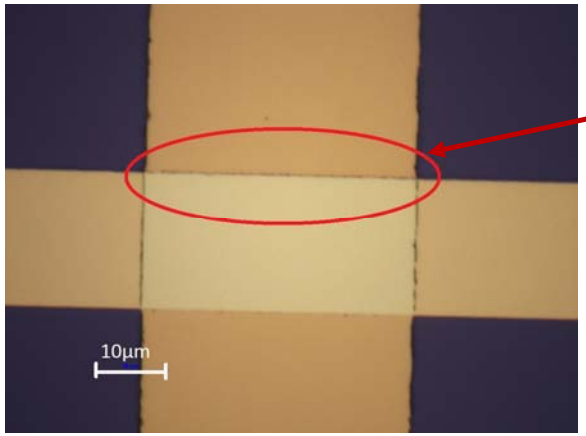
Work in progress:

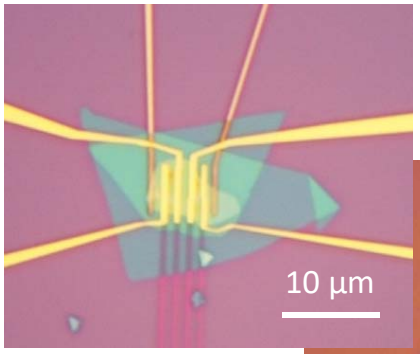
- ✓ More statistics on electrical characterization before and after grafting at low T
- ✓ AFM analysis of grafting
- ✓ Insertion of local top gate…playing with 2D materials
- ✓ Optical gating

Hot pick-up technique (J. Rastikian, S. Timpa, C. Barraud)

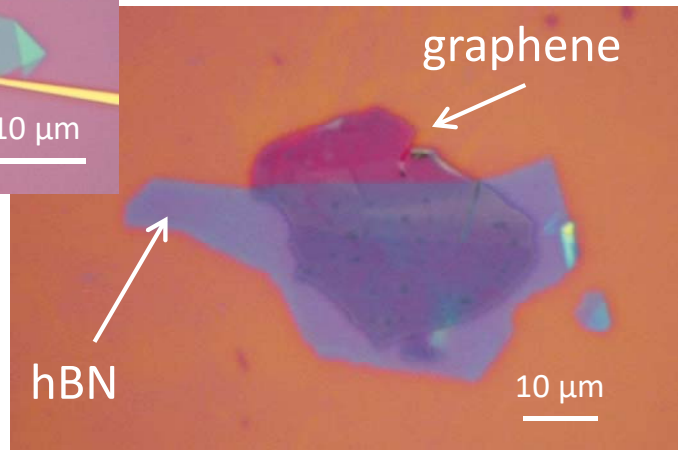


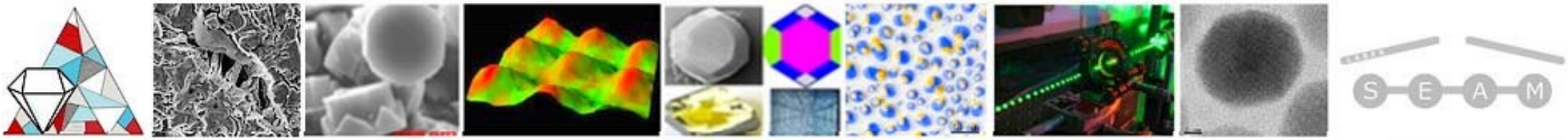
F. Pizzocchero et al., Nat. Comm. 7 (2016) 11894





S. Timpa,
Master 2 internship





Thank you!