



Queen Mary

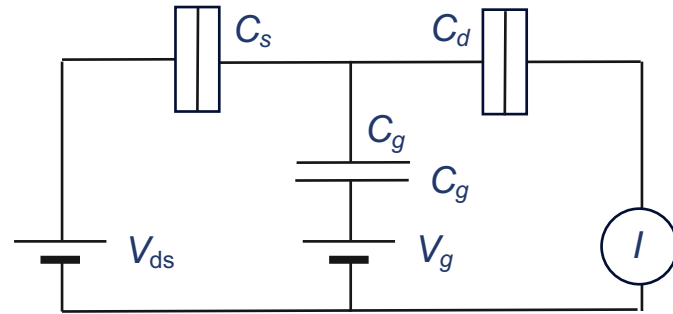
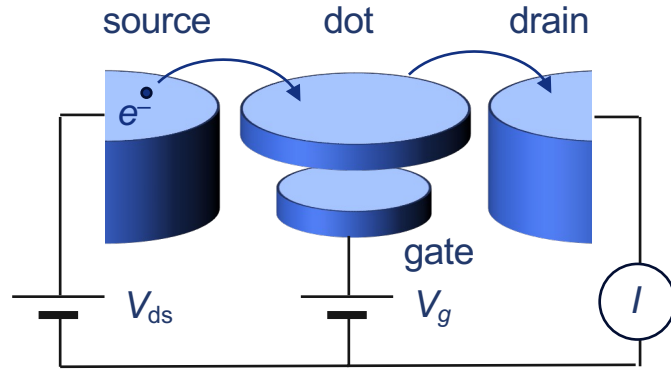
University of London

Science and Engineering

Carbon-based materials for room temperature single-electron devices (and why it pays to know a chemist)

Jan Mol

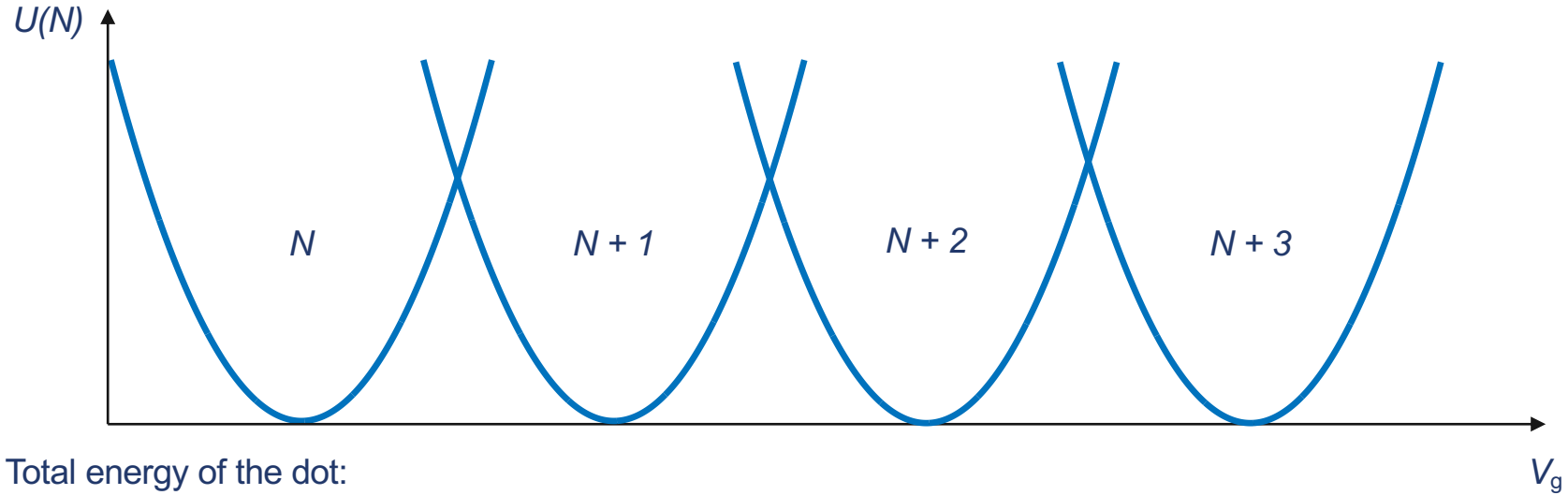
Single electron transistors



Total energy of the dot:

$$U(N) = \frac{1}{2} \frac{[-|e|(N - N_0) + C_s V_s + C_d V_d + C_g V_g]^2}{C_s + C_d + C_g}$$

Single electron transistors



Total energy of the dot:

$$U(N) = \frac{1}{2} \frac{[-|e|(N - N_0) + C_s V_s + C_d V_d + C_g V_g]^2}{C_s + C_d + C_g}$$

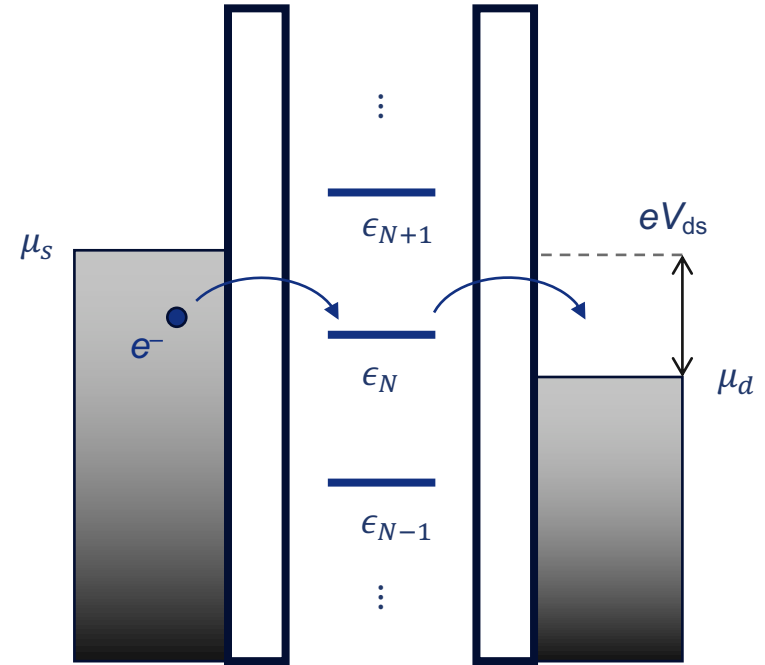
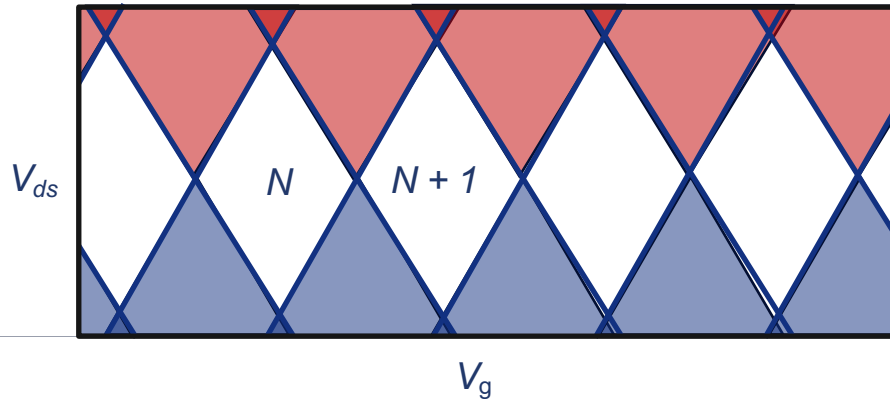
Single electron transistors

Energy difference (single-particle energy level):

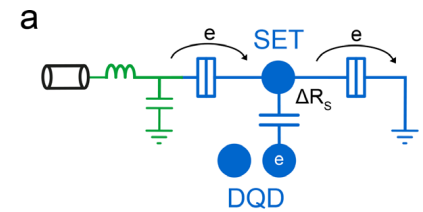
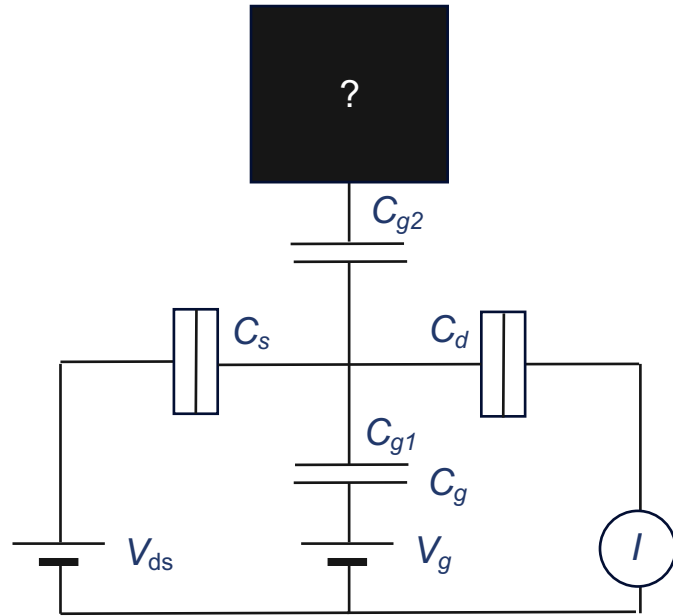
$$\epsilon_N = \left(N - N_0 - \frac{1}{2}\right) E_C - \frac{E_C}{|e|} (C_s V_s + C_d V_d + C_g V_g)$$

with

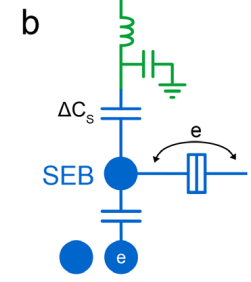
$$E_C = \frac{e^2}{C_s + C_d + C_g} N$$



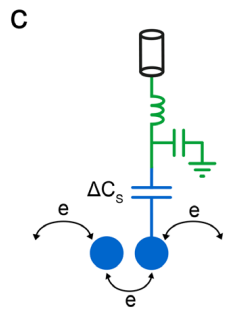
Quantum electrometer



RF-SET charge sensing

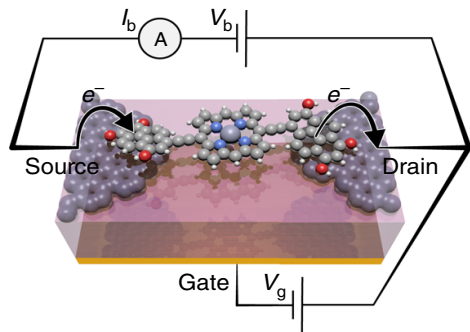


Dispersive charge sensing



In-situ dispersive readout

Measuring quantum transport

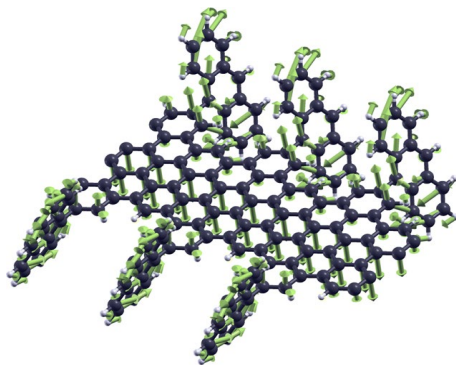


Understanding resonant charge transport through weakly coupled single-molecule junctions.

Thomas *et al.*

Nat. Commun. **10**, 4628 (2019)

Measuring quantum motion

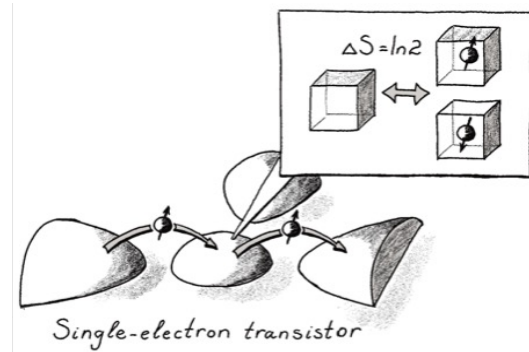


Exceptionally clean single-electron transistors from solutions of molecular graphene nanoribbons.

Niu *et al.*

Nat. Mater. **22**, 180–185 (2023)

Measuring quantum entropy

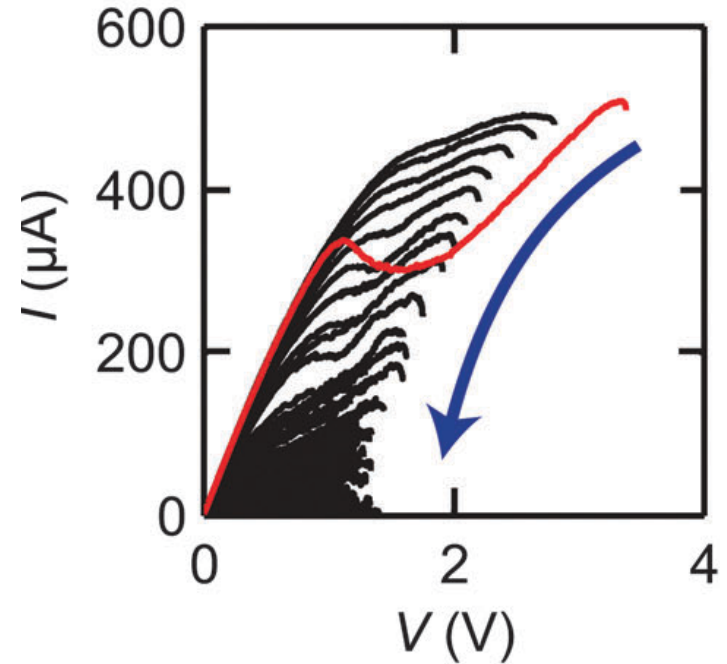
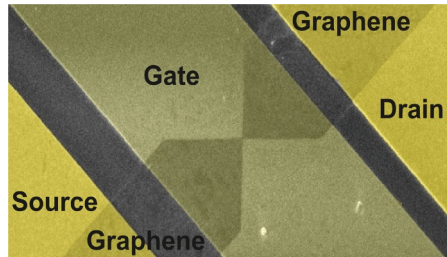
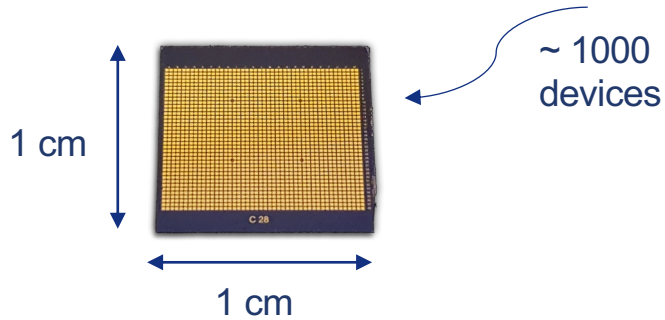


Electronic measurements of entropy in meso- and nanoscale systems.

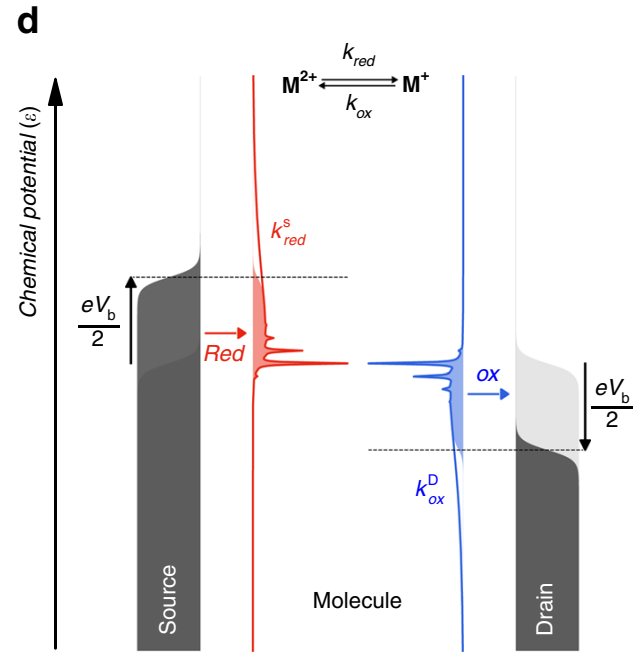
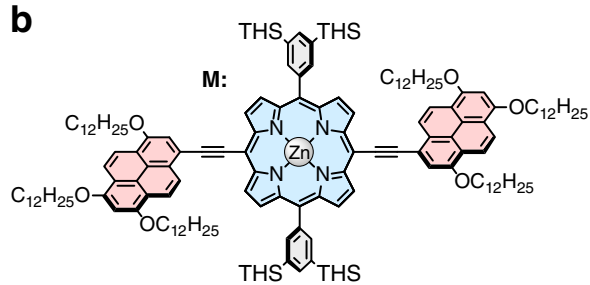
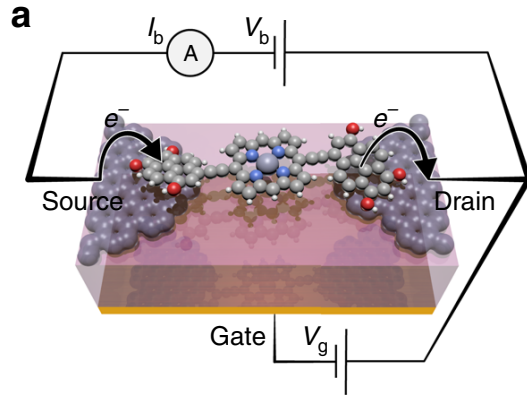
Pyurbeeva *et al.*

Chem. Phys. Rev. **3**, 041308 (2022)

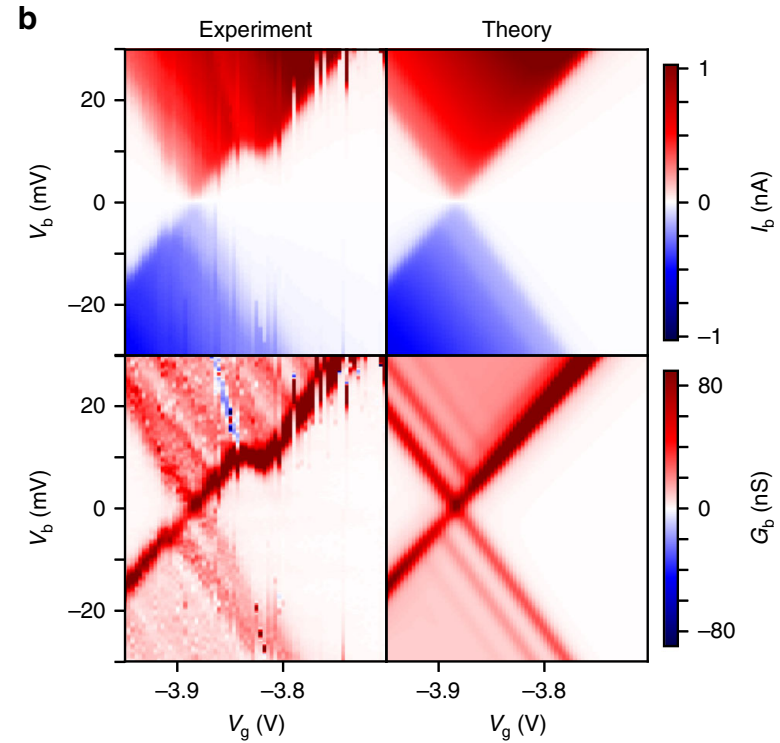
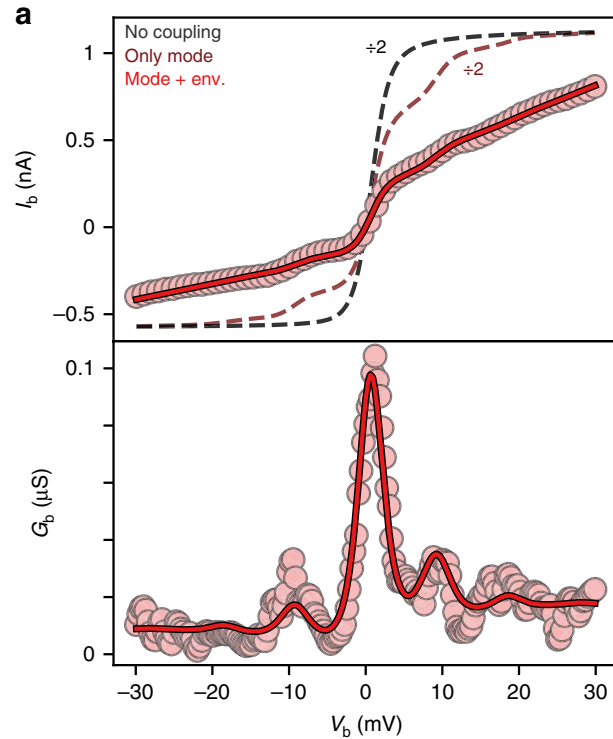
Single-molecule transistors



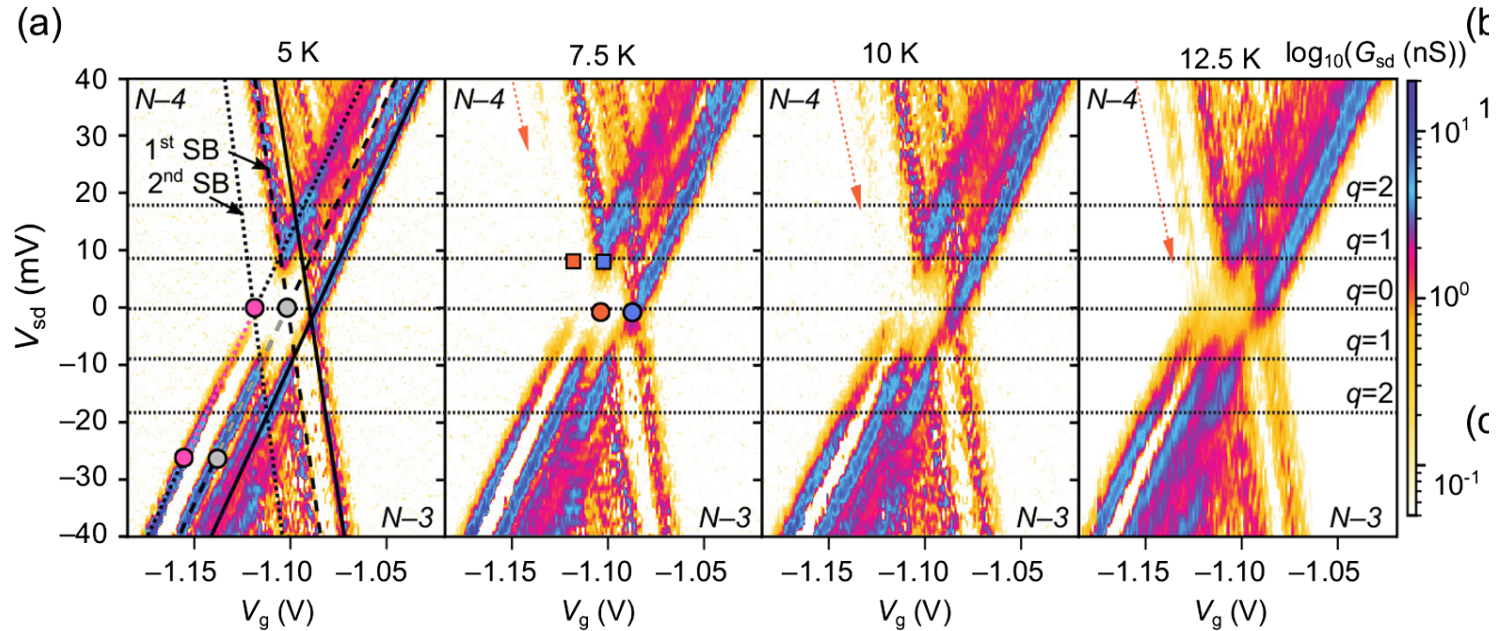
Single-molecule transistors



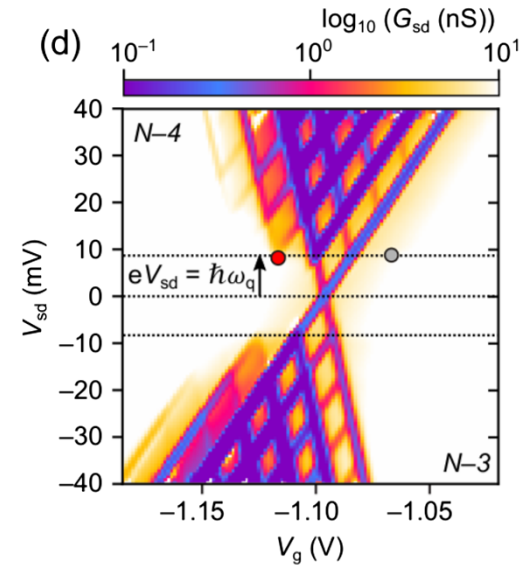
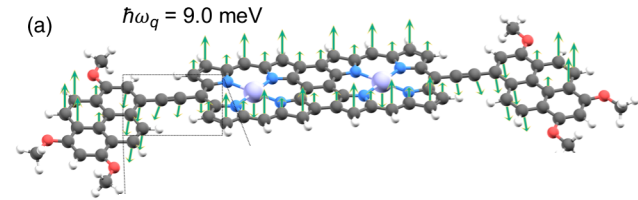
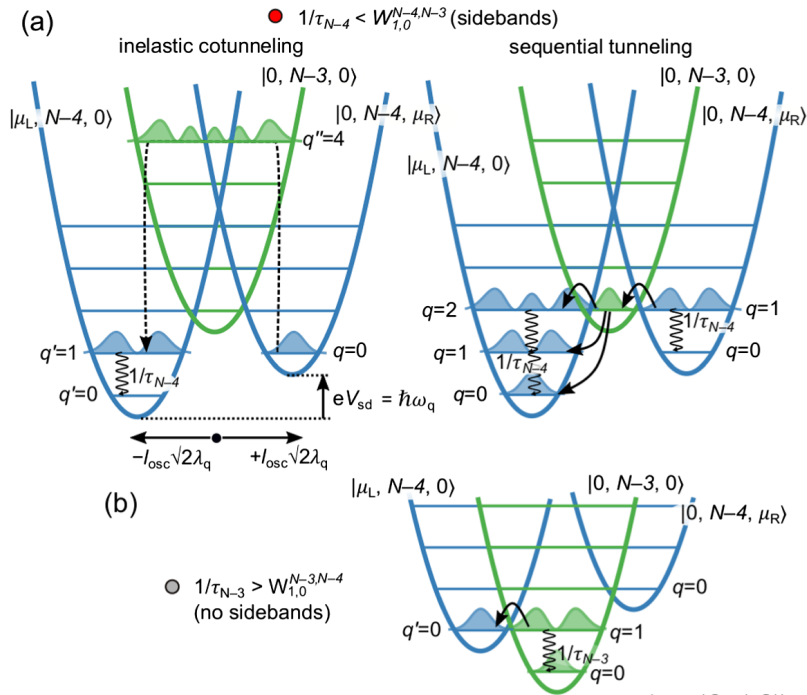
Single-molecule transistors



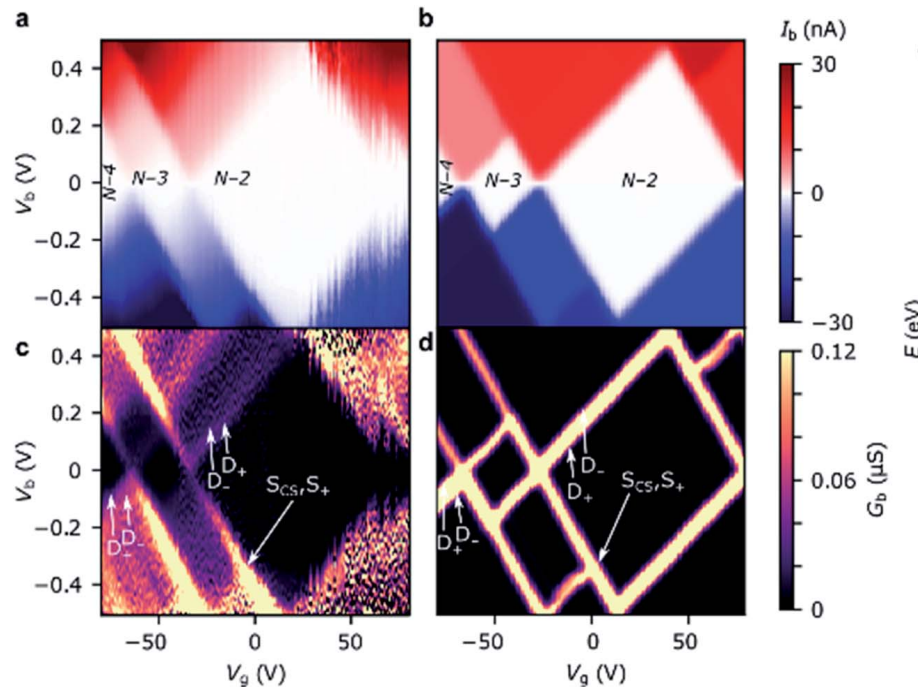
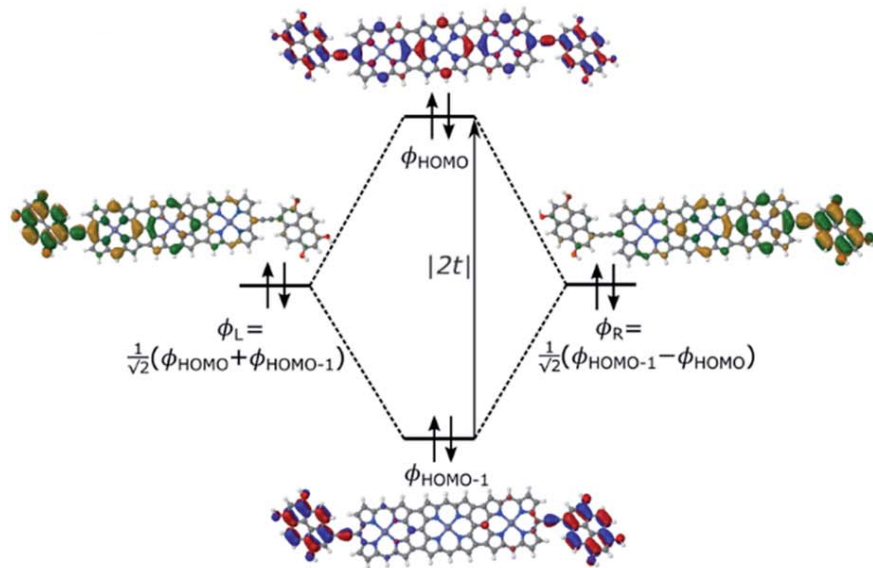
Non-equilibrium vibrations



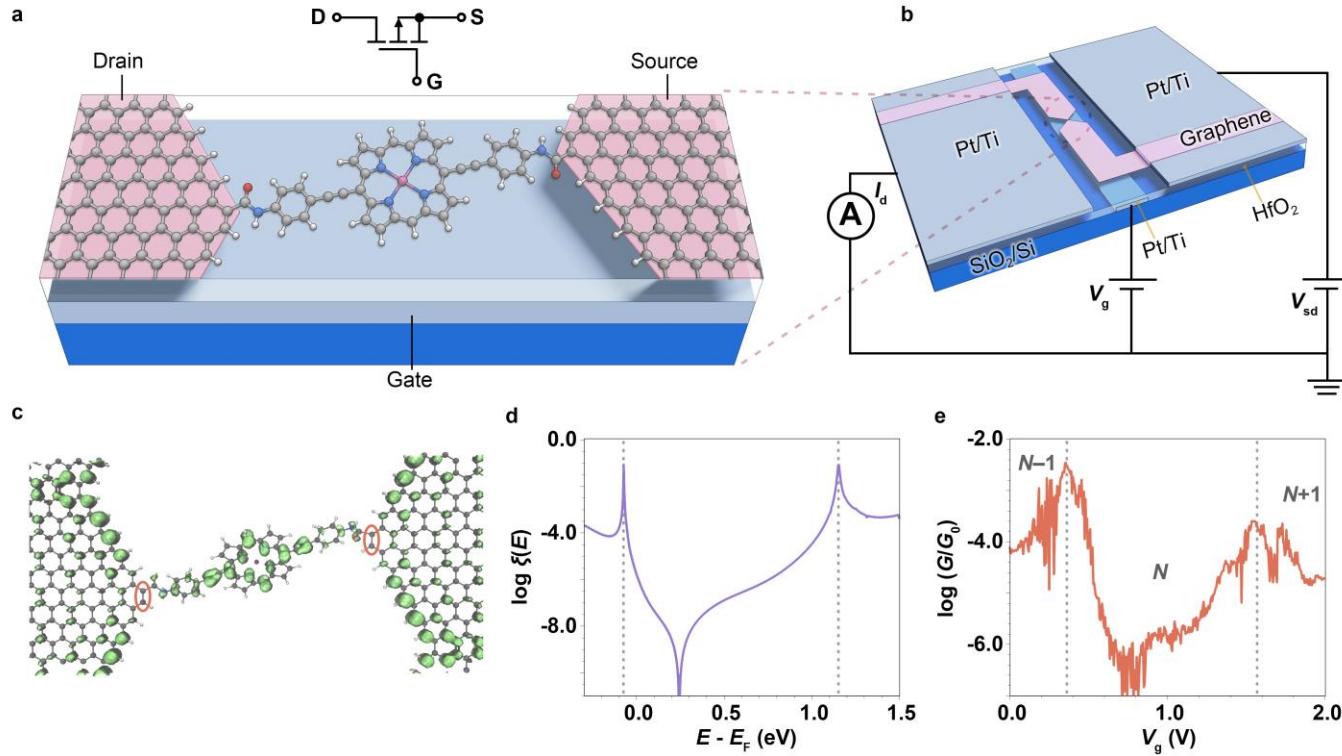
Non-equilibrium vibrations



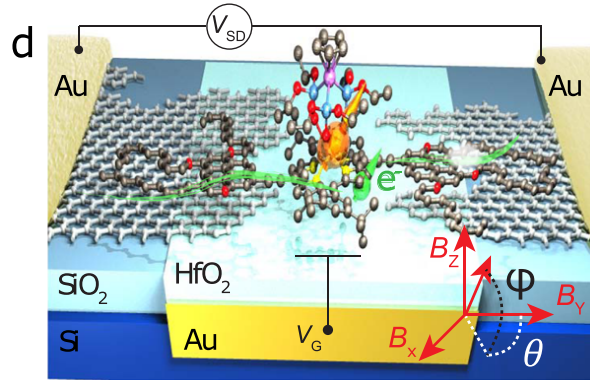
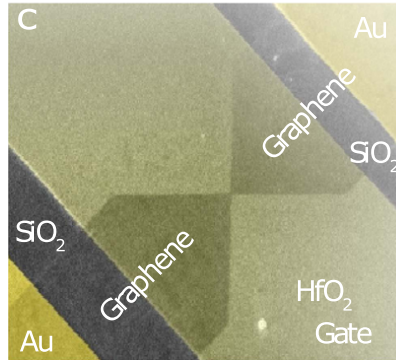
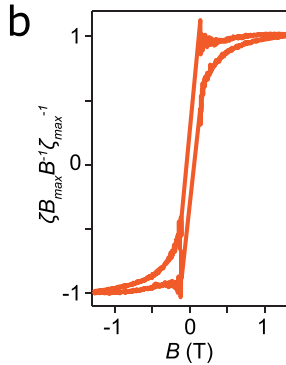
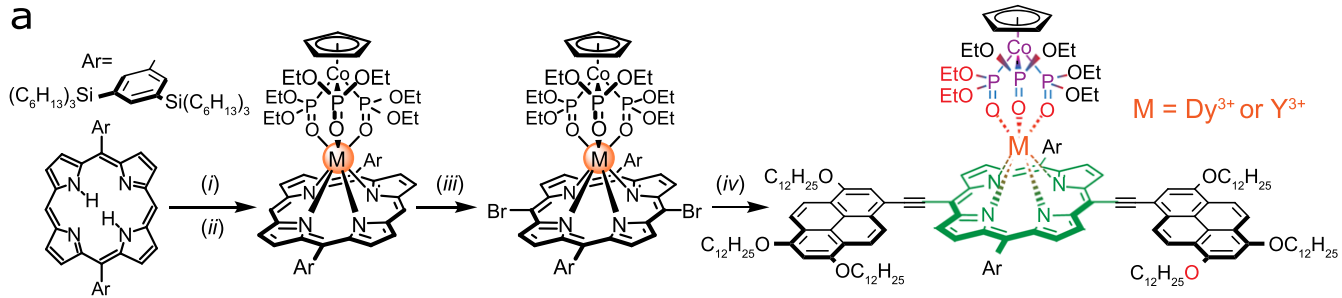
Engineering quantum properties



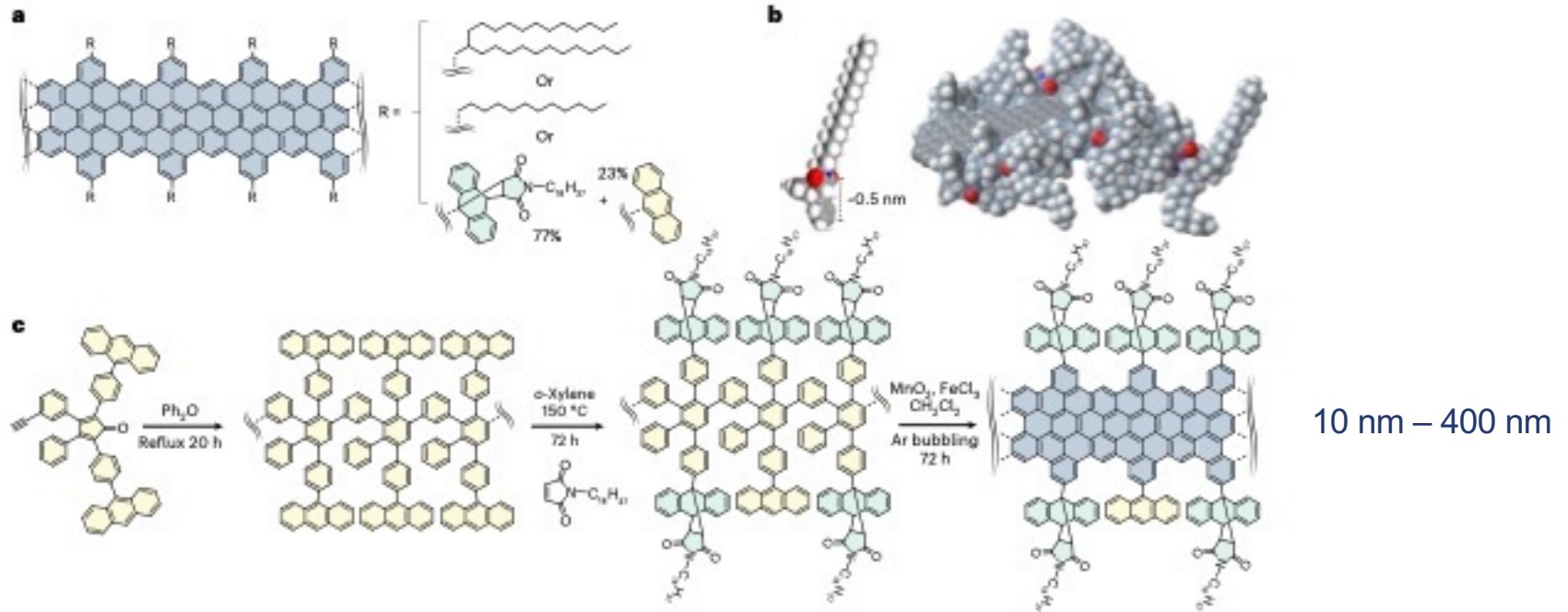
Engineering quantum properties



Engineering quantum properties

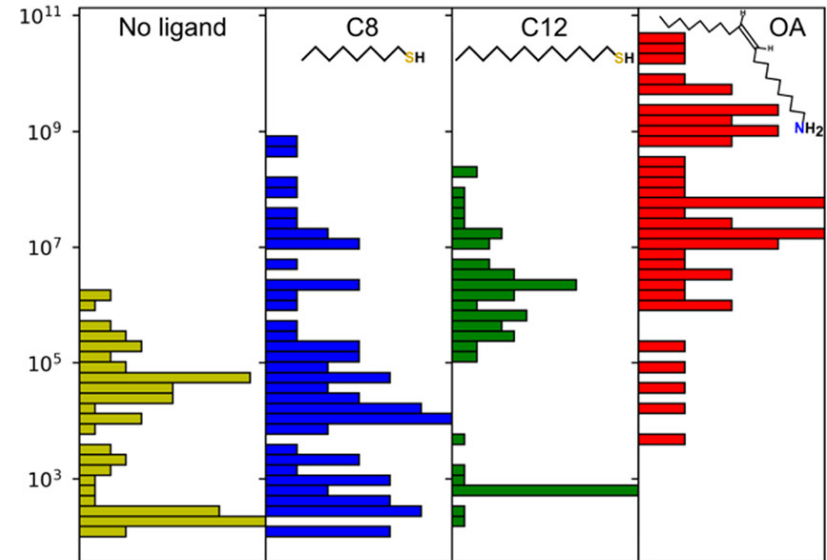
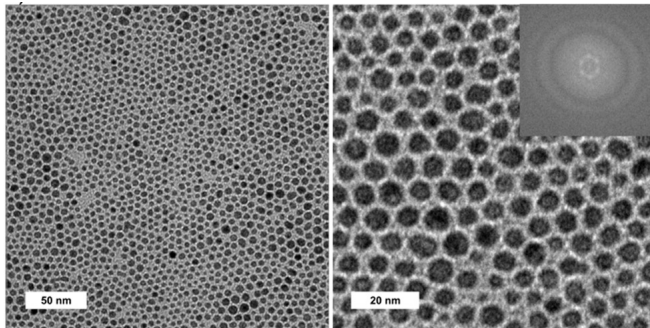
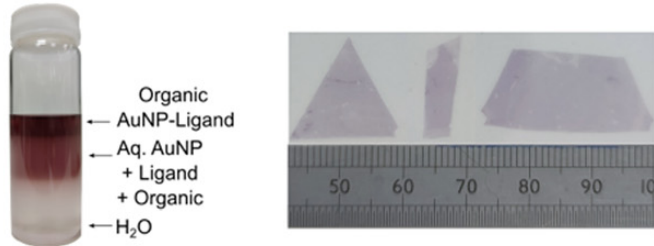


Scaling up

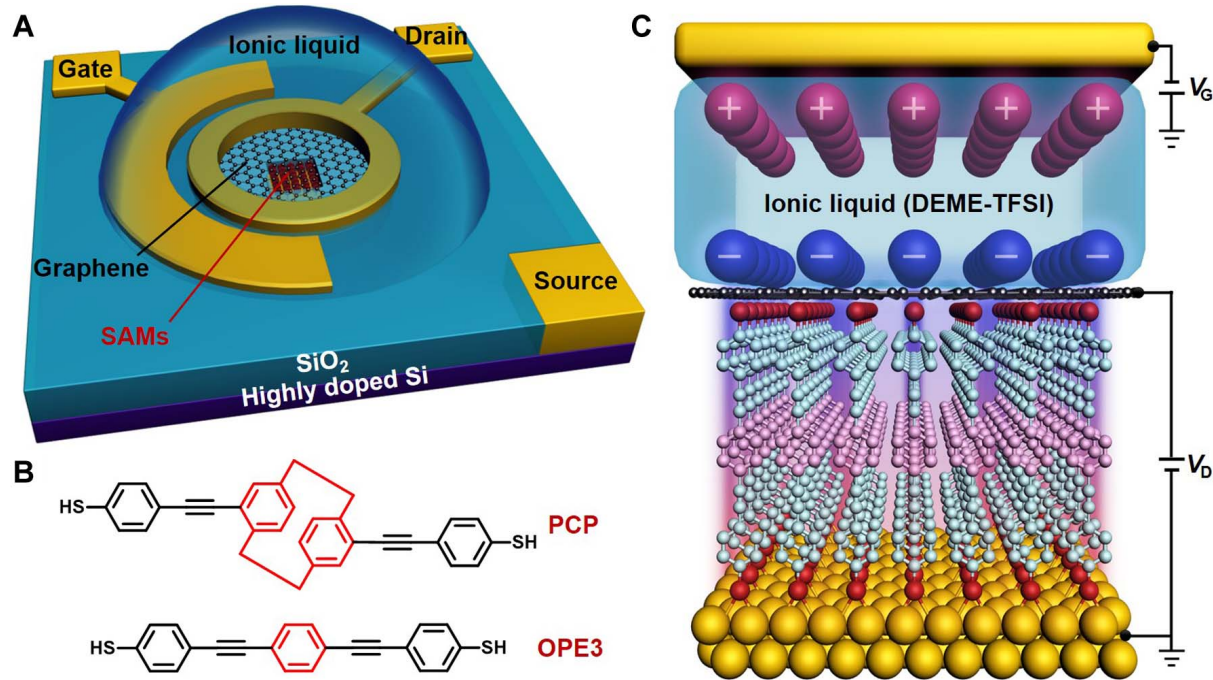


Scaling up

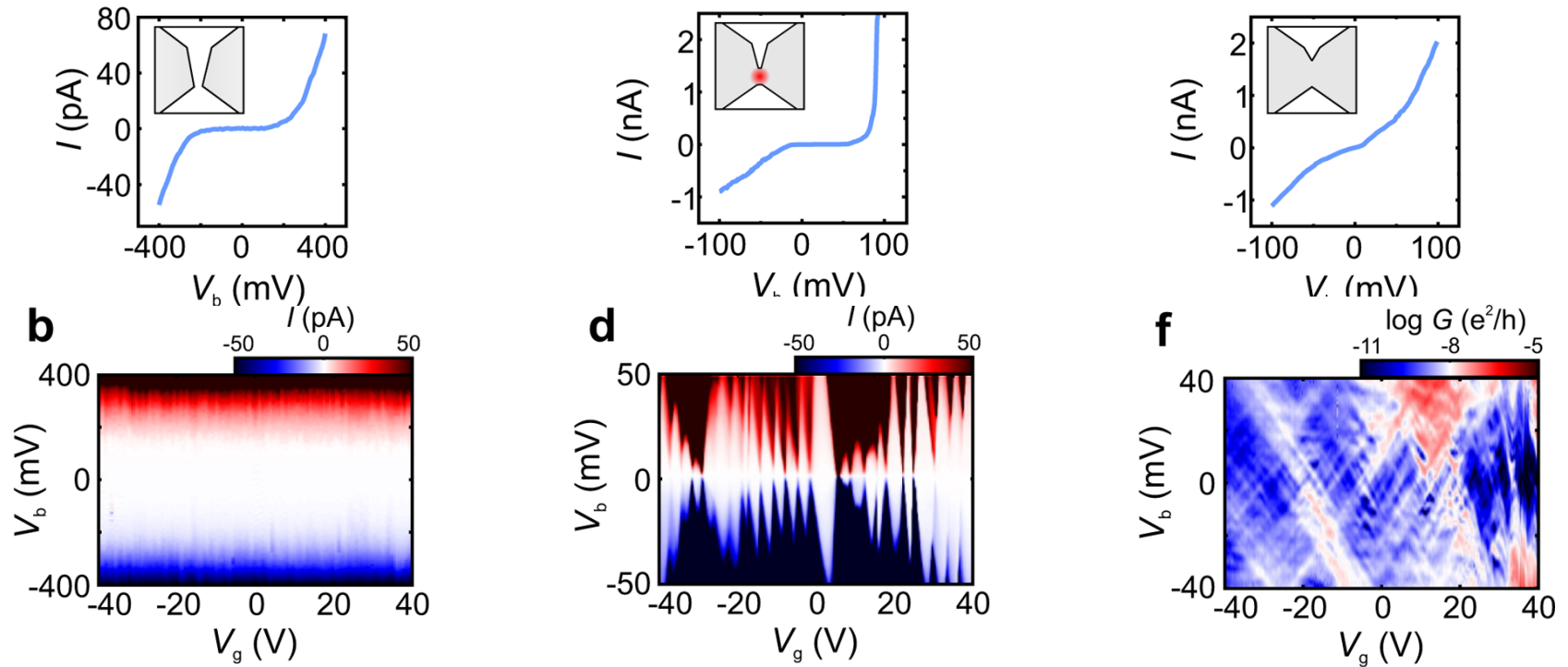
Phase exchange & monolayer assembly



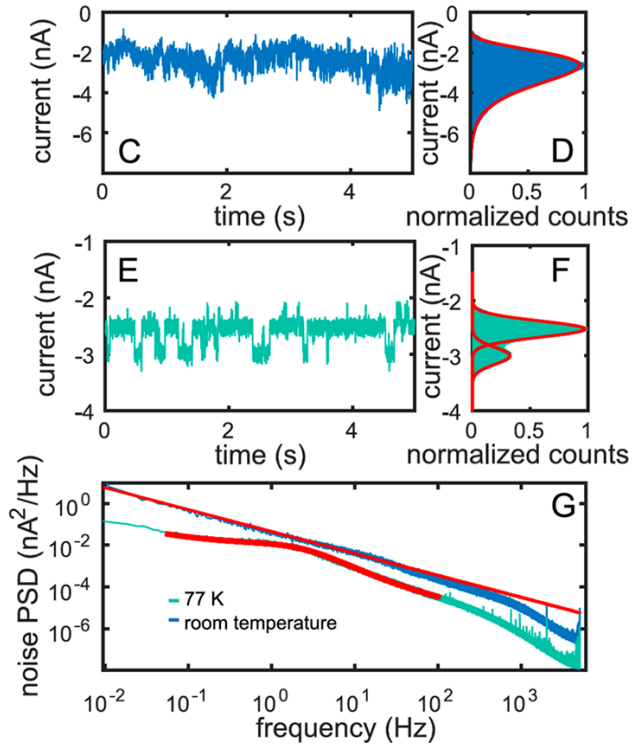
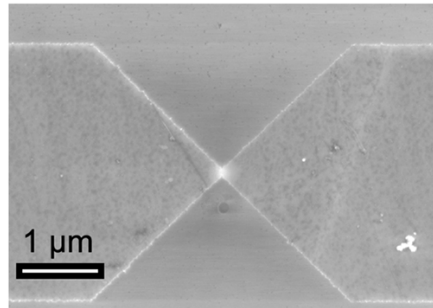
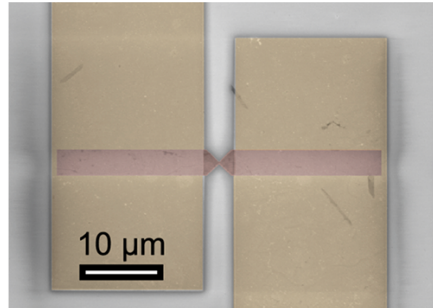
Scaling up



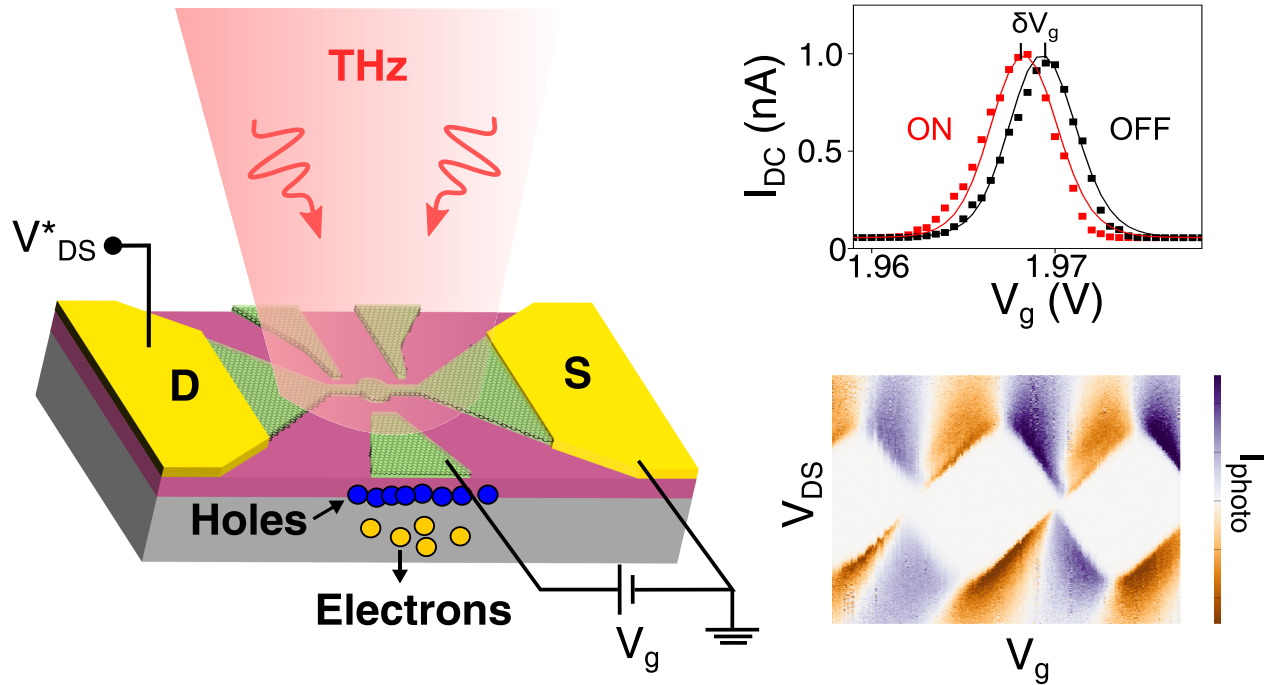
Graphene quantum dots



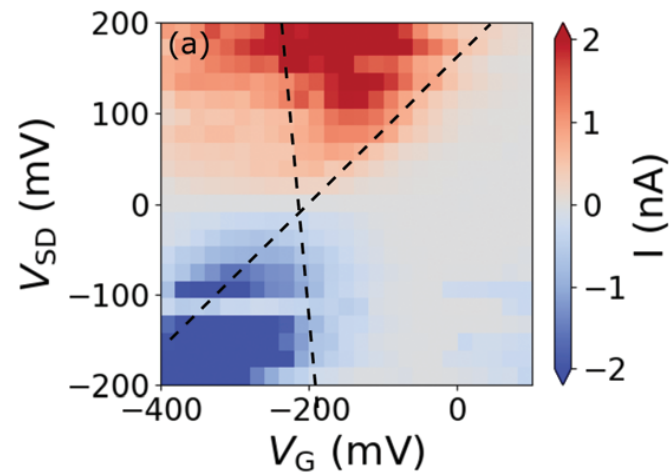
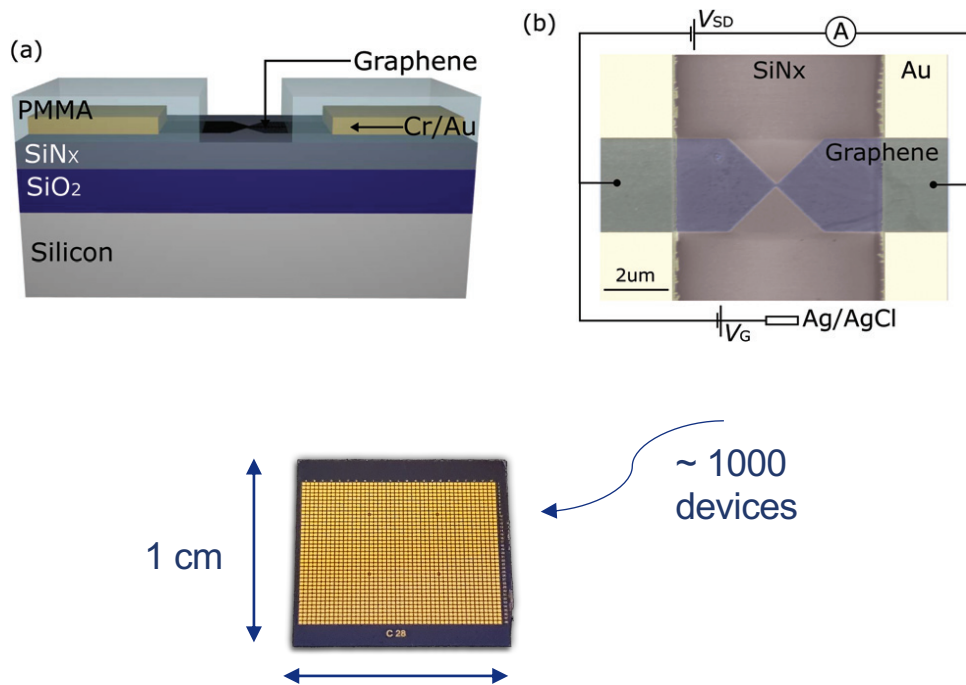
Single-electron charge sensing



Single-electron charge sensing



Room temperature operation



Acknowledgements

QMUL

James Thomas

University of Oxford

Harry Anderson

UC Louvain

Pascal Gehring

Rice University

Jakub Sowa



**UK Research
and Innovation**

A*STAR IMRE

Aaron Lau

Johnson Goh

University of Waterloo

Jonathan Baugh

University of Cape Town

Mark Blumenthal



Oak Ridge National Lab

Stephen Jesse

Ondrej Dyck

Delft University of Technology

Herre van der Zandt

Heriot-Watt University

Erik Gauger



**Royal Academy
of Engineering**