MEETING OF DIRECTORS
BIPM

17 October 2019

Thomas Grenon – LNE

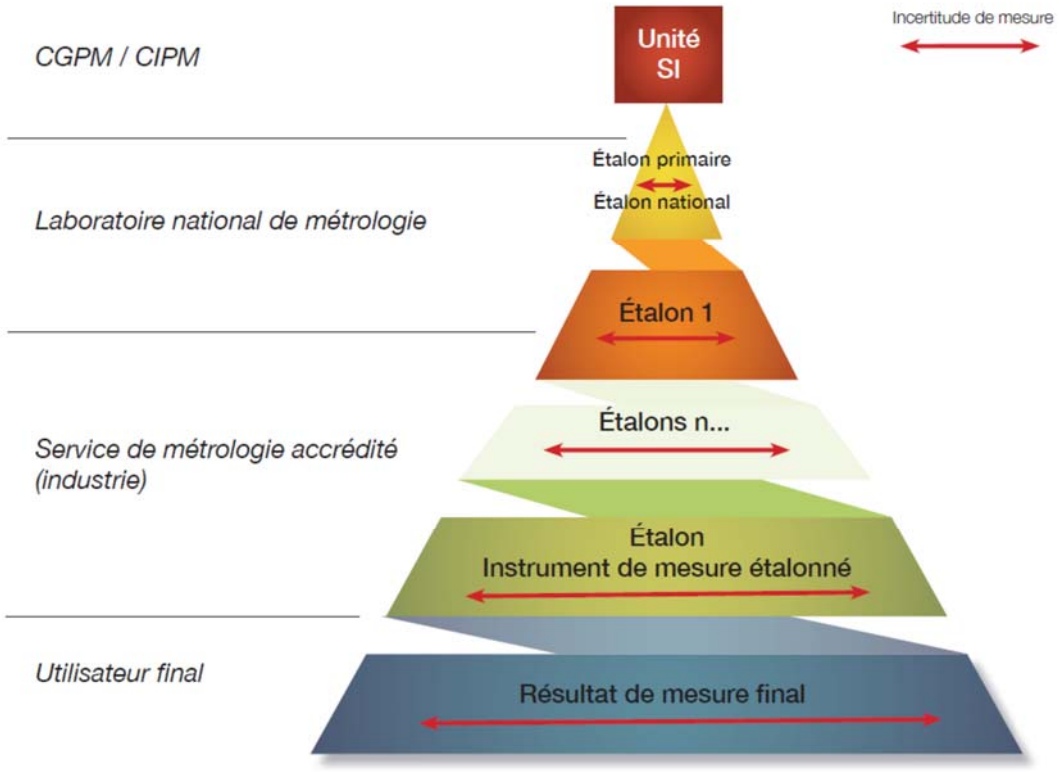
October 17, 2019

LABORATOIRE NATIONAL DE MÉTROLOGIE ET D'ESSAIS

New opportunities with strategic significance for the future in mass and related quantities

LABORATOIRE NATIONAL DE MÉTROLOGIE ET D'ESSAIS

From references to user



We are all aware of the necessity of traceable measurements to the SI for science, trade, security and safety of citizens, to provide comparable measurements.

When we are close to users (far from the references), « precision » of measurements are degraded.

It is essential to get the lowest uncertainties as possible in view to disseminate, and answer to industrial and societal needs.

Traceability of measurements

To ensure exact measurements and to provide independent methods

To ensure the metrological comparability of measurement results (e.g. via the CIPM MRA)
Possibility to compare results of the R&D and methods developed in different countries

To ensure middle and long term stabilities of reference (e.g. to follow the climate change)
Long term surveillance of evolution

To avoid too much duplications on analysis, in increasing the confidence in the results provided

To answer to regulation and normative requirements

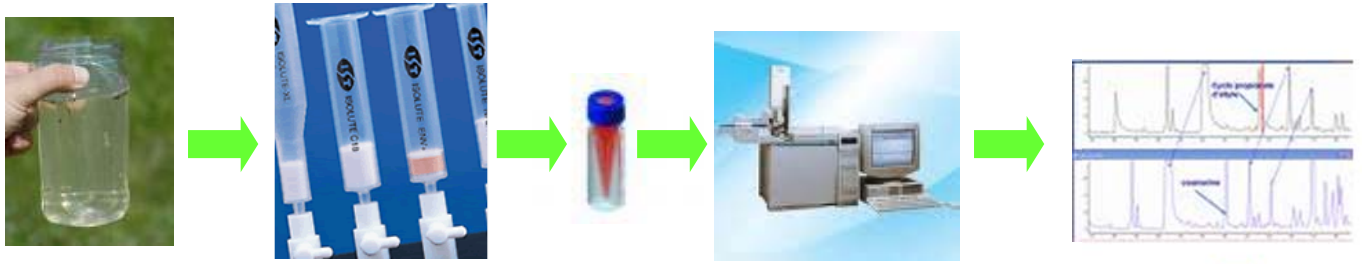
- Directive 98/79/CE of EU related to medical devices (IVD)
- Different standards : ISO EN 17025, 15189 …

Some examples
- environment
- sciences & techniques

LABORATOIRE NATIONAL DE MÉTROLOGIE ET D'ESSAIS

Dosing pollutants in water, air, soil

Example of glyphosate analysis in water (lake)



Concentration of glyphosate in water (ng/l)

LABORATOIRE NATIONAL DE MÉTROLOGIE ET D'ESSAIS

Mechanic and electronic fields

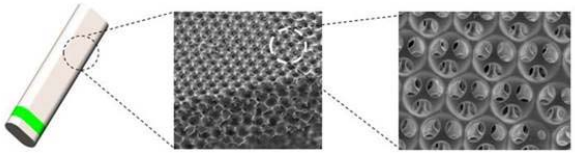
Ophthalmic implants M = 0,7 mg,
Uncertainty (u_r) *requested*: 10 µg

at LNE: u_r (1 mg-OIML) = 1 µg

- metrology for mass and force

- nanometrology (dim., elect., therm.)

Calibration of sensitivity of probes to forces and movements
Calibration of constant stiffness of AFM cantilever



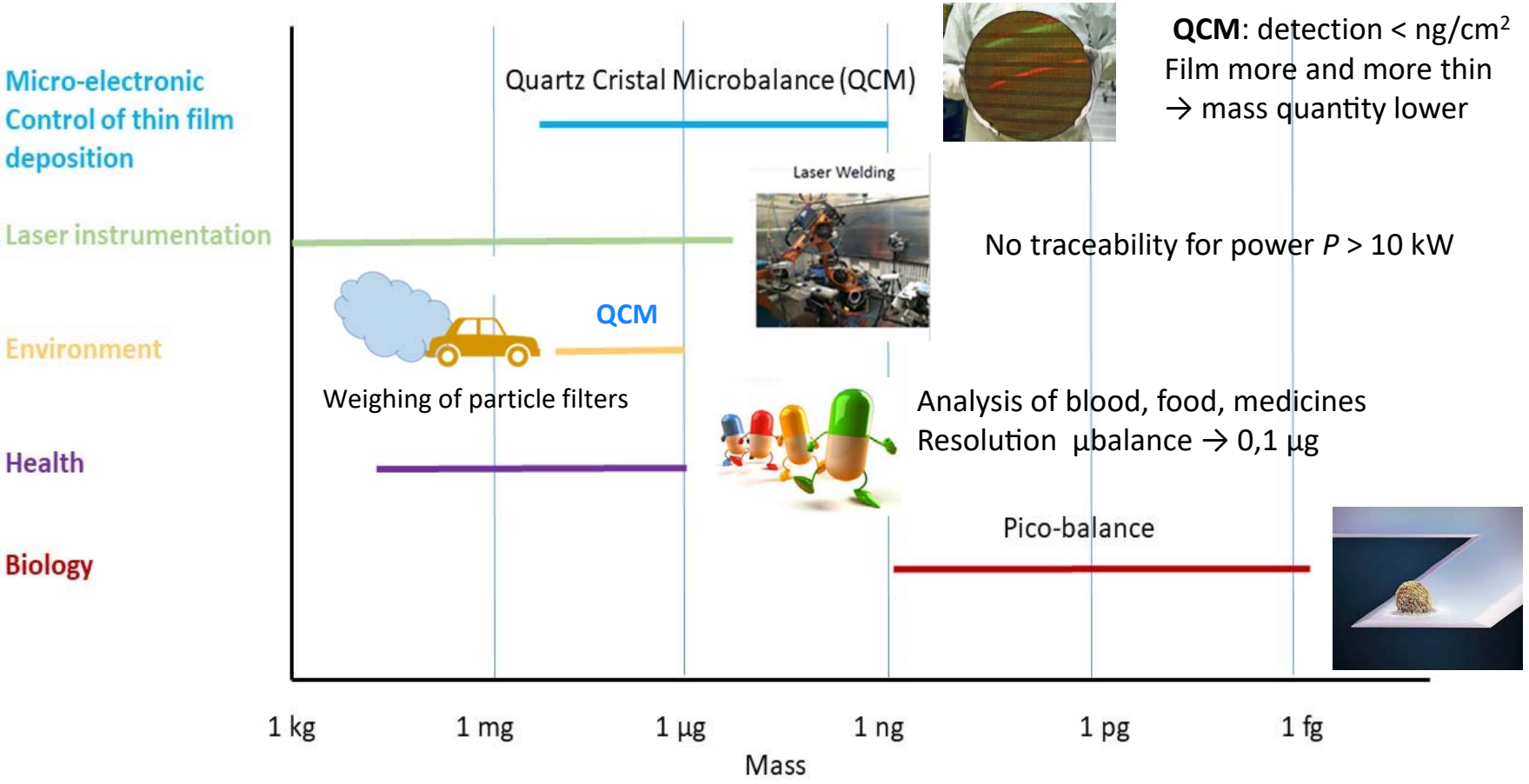
- metrology of nanoparticles

Reliable and reproducible determination of existing forces, at the interface between a nanoparticle and a cellular wall

- metrology in chemistry and biology

Reduction of cost for pure compound => 1 k€/mg
Measurements of the mass of pure compounds => M = 1 mg with even possibility for 100 µg in flake or lamellar of 1 g with u_r < 100 µg/g

Very low masses… metrology needs



QCM: detection < ng/cm^2
Film more and more thin
→ mass quantity lower

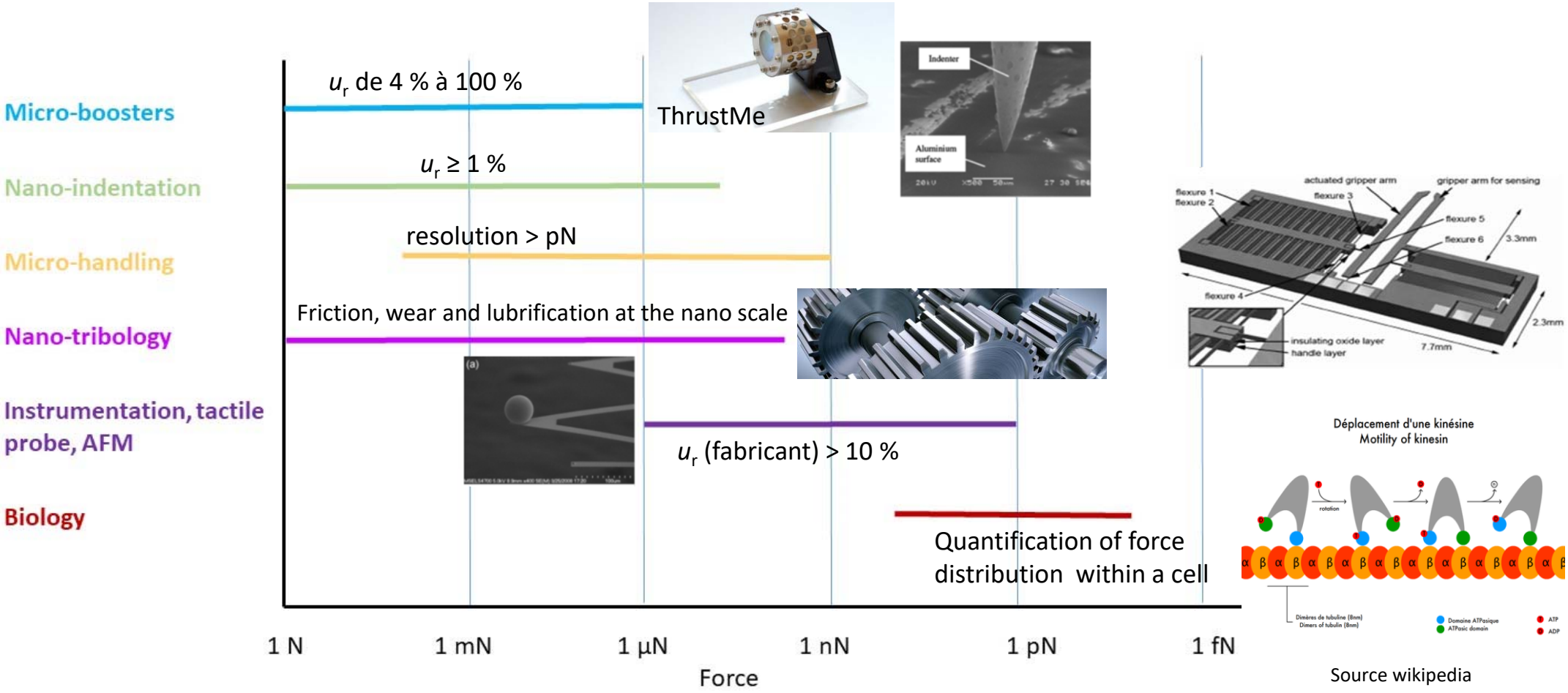
No traceability for power P > 10 kW

Analysis of blood, food, medicines
Resolution µbalance → 0,1 µg

Modelling of the mass evolution of cell

Data dispersion ≈10%

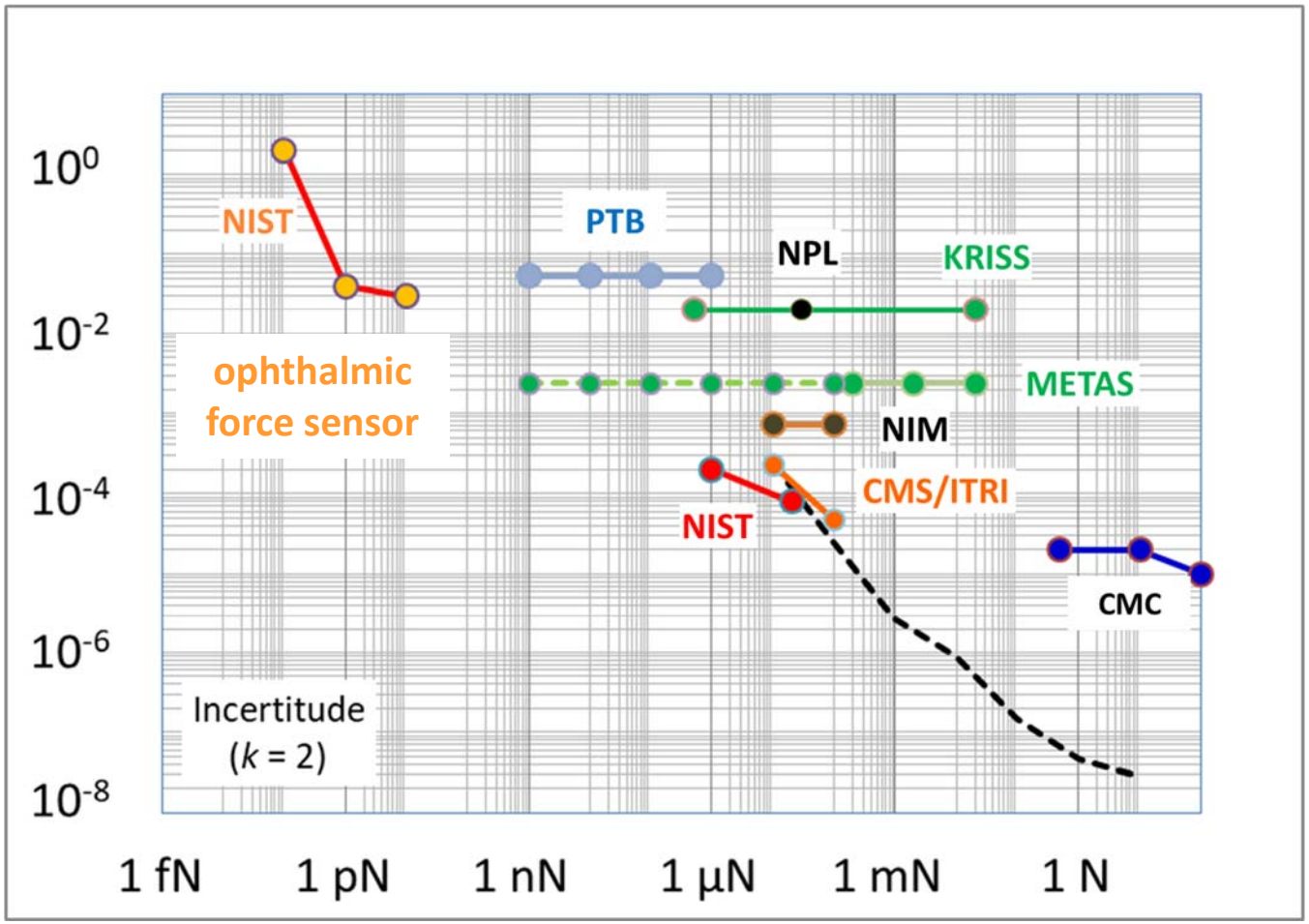
Very low forces … metrology needs



Source wikipedia

LABORATOIRE NATIONAL DE MÉTROLOGIE ET D'ESSAIS

State of the art: very low forces $F < 1$ mN



Electrostatic force balance
NIST, NPL, PTB, CMS/ITRI, NIM

Balance with electromagnetic compensation
METAS (Mettler Toledo)

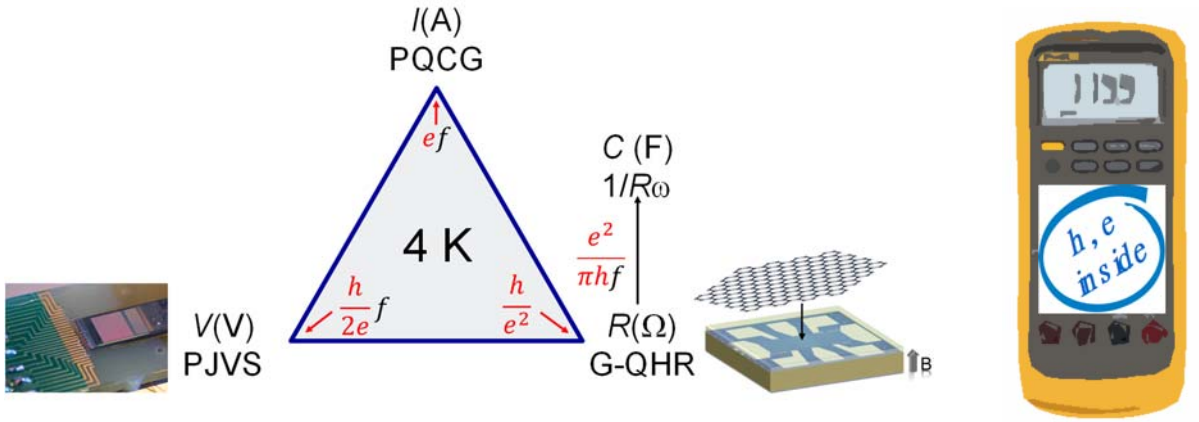
Commercial micro-balance & nanopositioning
KRISS, MIKES

LABORATOIRE NATIONAL DE MÉTROLOGIE ET D'ESSAIS

For the electric field and micro-electronic

System be able to realise the volt, the ohm, the ampere and the farad, only with the constants *h* and *e*

=> To combine a voltage Josephson standard and quantum Hall resistance standard in a unique cryogenic system (Programmable Quantum Cryogenic Comparator – PQGC)



Opportunity

Cryo-magnetic system « without liquid helium » with pulsed tubes

Resistance standards with graphene compatible with voltage Josephson standard

Quantum generator of current intensity

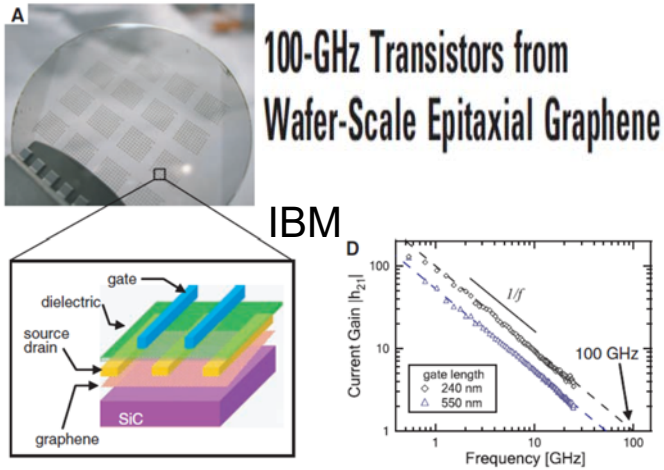
Impedance bridge

Towards a better dissemination of the revised SI

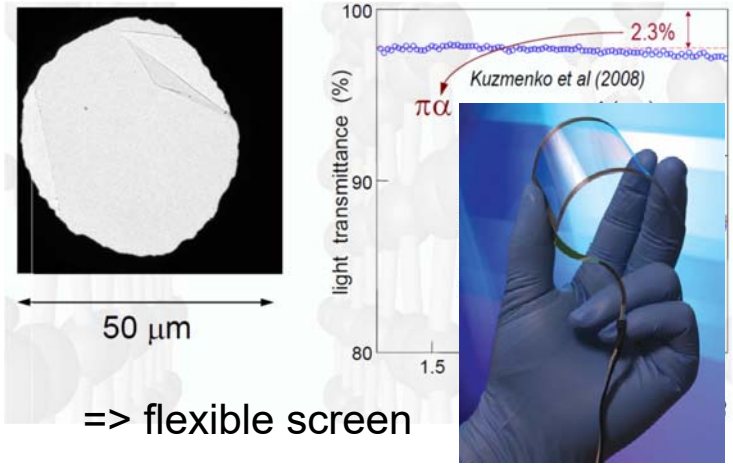
For the electric field and micro-electronic
Application to graphene

Ultra-fast analogic transistors

$v_F=10^6$ m/s



Conductive transparent electrode

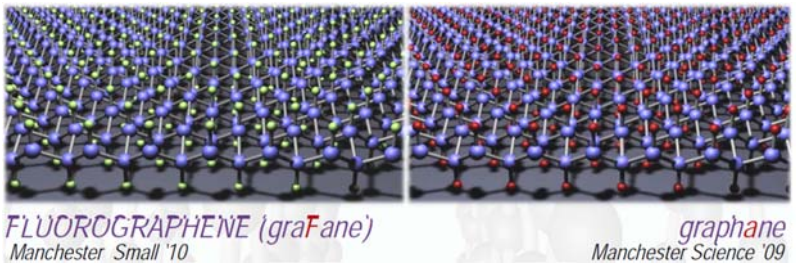


=> flexible screen

Gas detector : one molecule

Ingénierie du graphène

Stockage d'hydrogène



Conclusion

To innovate more, answer to new needs, it is essential to provide reliable characterisations on the middle and long term views, with repeatable and comparable measurements.

Metrology is a vital support for innovation and for exploring the fields of extreme measurements

- the nano world
- complex environments
- range of measurements at the “edges”: e.g. very high temperature (fusion), cryogenics

New expressed needs in disruptive technologies or new fields of development

⇒ quantum technologies, additive manufacturing, new applications, digitalisation of our environment and word, etc…

⇒ with always more demands in term of uncertainty