

The Revised SI: Quantum electrical standards are back into the SI!

Definition of the kilogram

$$h = 6.626\,070\,15 \times 10^{-34} \text{ Js}$$

Planck constant

Definition of the ampere

$$e = 1.602\,176\,634 \times 10^{-19} \text{ C}$$

Charge of the electron

Quantum Hall standard
for resistance

$$R = \frac{1}{n} \frac{h}{e^2}$$

(n : quantum number)

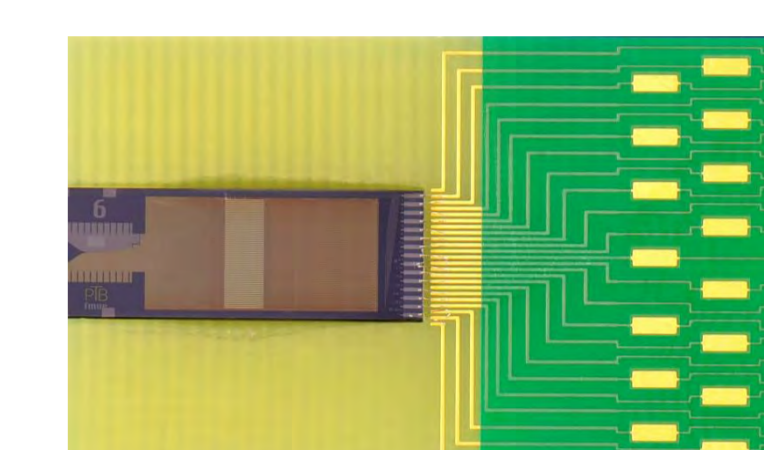
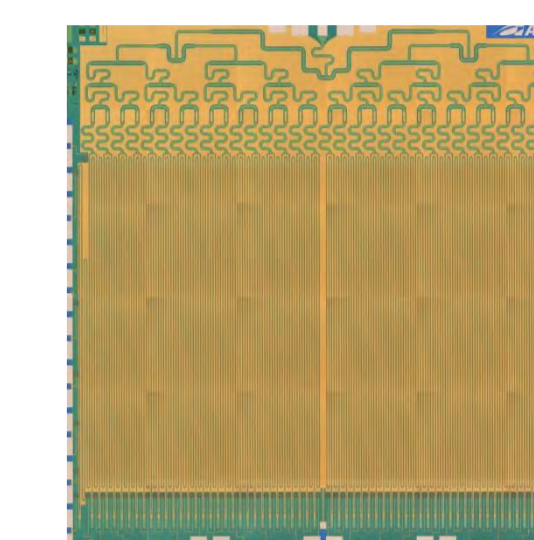
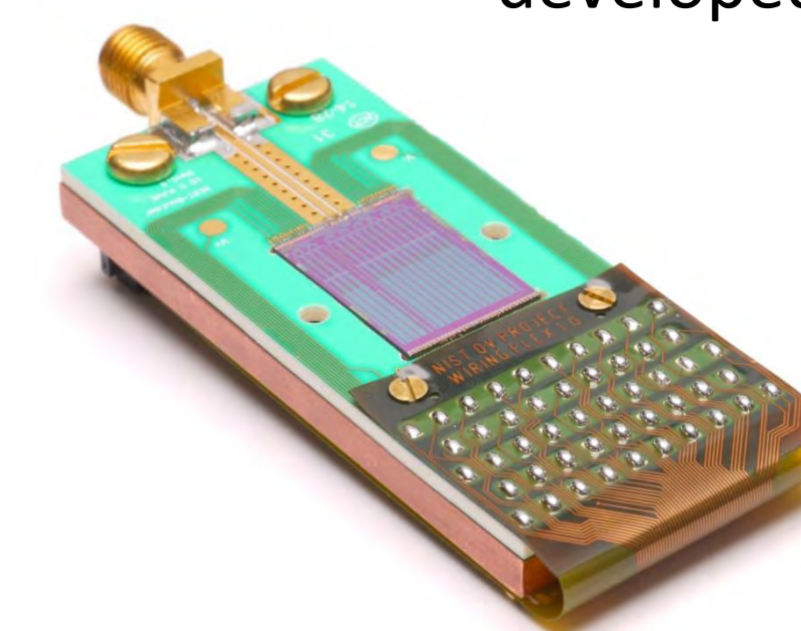
Josephson quantum
standard for voltage

$$U = n f \frac{h}{2e}$$

(n : quantum number, f : frequency)



graphene QHR sample,
developed by PTB

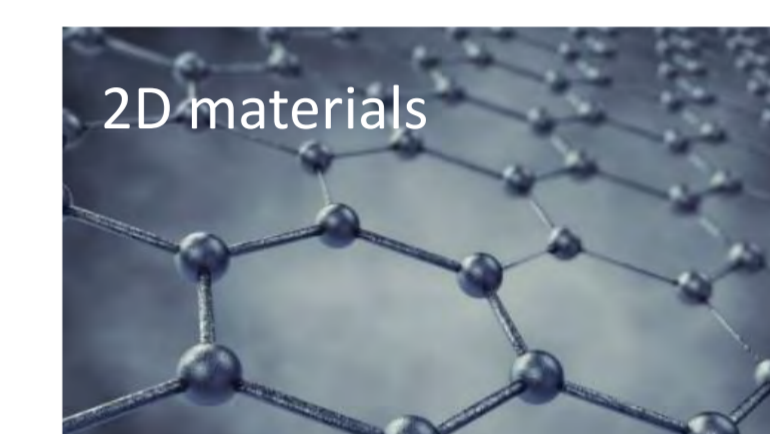


programmable Josephson
arrays (NIST, NMIJ, PTB)

Global forum for progressing the state of the art

Scientific presentations at CCEM meetings (2019, 2021) and workshop on metrology for radiofrequencies and microwaves (2019):

- Low current measurements for ionization chambers
- S-Parameter measurements in coaxial systems
- Industrial metrology challenges induced by 5G
- Plasmonic and photonic technologies for mm-wave wireless communications
- Towards a quantum standard for radio-frequency electric fields
- HF characterization at sub-micrometer scales using on-wafer and SPM techniques
- Quasi-Optical Design and Manufacturing Techniques for mm-wave Remote Sensing Applications



2D materials
HF measurements to improve
knowledge of low dimensional devices



Optical distribution of microwave
signals on satellites

Facilitating dialogue between NMIs and stakeholders

Mise en pratique for the definition of the ampere and other electric units in the SI

Consultative Committee for Electricity and Magnetism

CCEM Guidelines for Implementation of the 'Revised SI'

Consultative Committee for Electricity and Magnetism

<https://www.bipm.org/en/publications/mises-en-pratique>

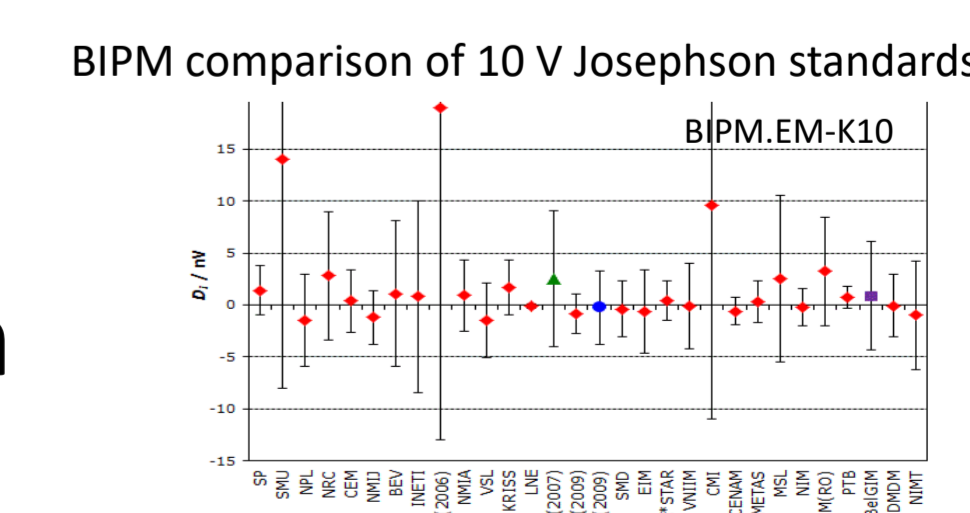
- Implementation of the revised SI – with small changes in the magnitude of the volt and the ohm - has not led to any problems in the stakeholder community!
- Series of CCEM webinars launched, recordings available on the YouTube channel 'The BIPM'



Supporting the CCRI in the development of a technique for measuring ultra-low ionization currents, eliminating the need of sealed radioactive sources

Global comparability of measurements

- Quantum standards have greatly increased comparability of EM measurements world-wide
- BIPM runs on-site comparisons of quantum standards at Member State NMIs
- Successful completion of CCEM-K4 (capacitance at 10 pF), coordinated by BIPM, first CCEM comparison in 'star' configuration, completed in 20 months
- CCEM covers many quantities: not all 198 calibration service categories can be covered by a comparison, so comparisons are strategically planned, preferably in 'star' configuration for improved efficiency
- New CMC review process with improved efficiency runs successfully under KCDB 2.0



CCEM comparison of 10 pF capacitance calibrations (the first CCEM comparison using star-scheme)

