

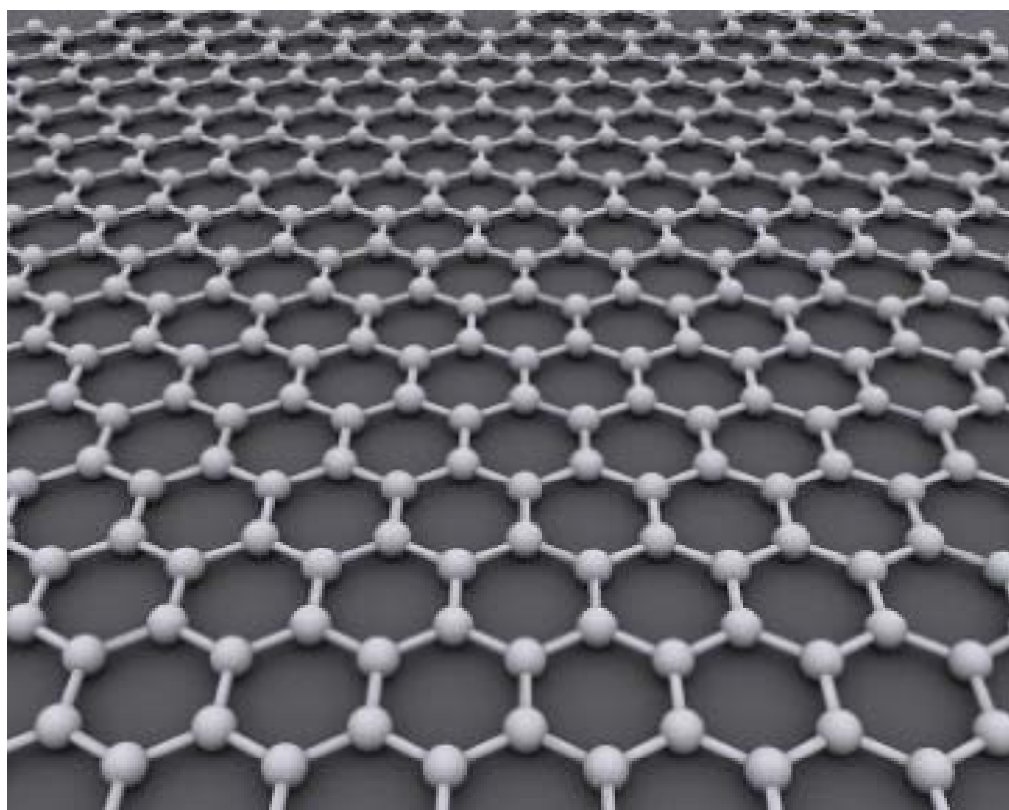
INRiM ACTIVITY ON GRAPHENE-BASED SENSORS FOR NO₂ MONITORING

Barbara Massessi, Enrica Pessana, Michela Segà
Istituto Nazionale di Ricerca Metrologica - Strada delle Cacce 91 – 10135 Torino, Italy -
E-mail: m.sega@inrim.it

SENSOR FABRICATION

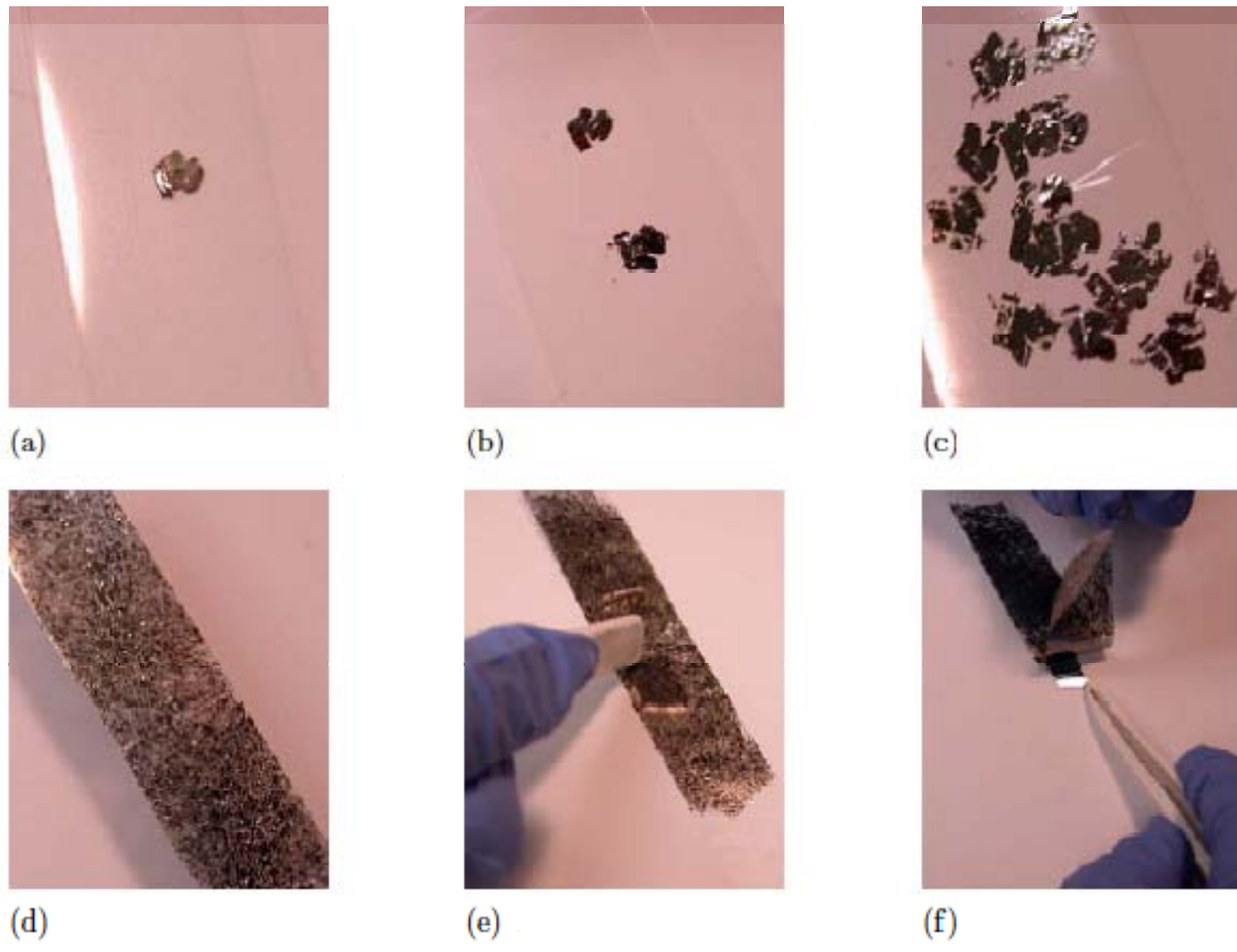
WHAT IS GRAPHENE?

- Graphene is pure carbon in the form of a very thin, nearly transparent sheet which can be described as a **one-atom thick layer of graphite**.
- Graphene is a crystalline allotrope of carbon **with two-dimensional properties**.



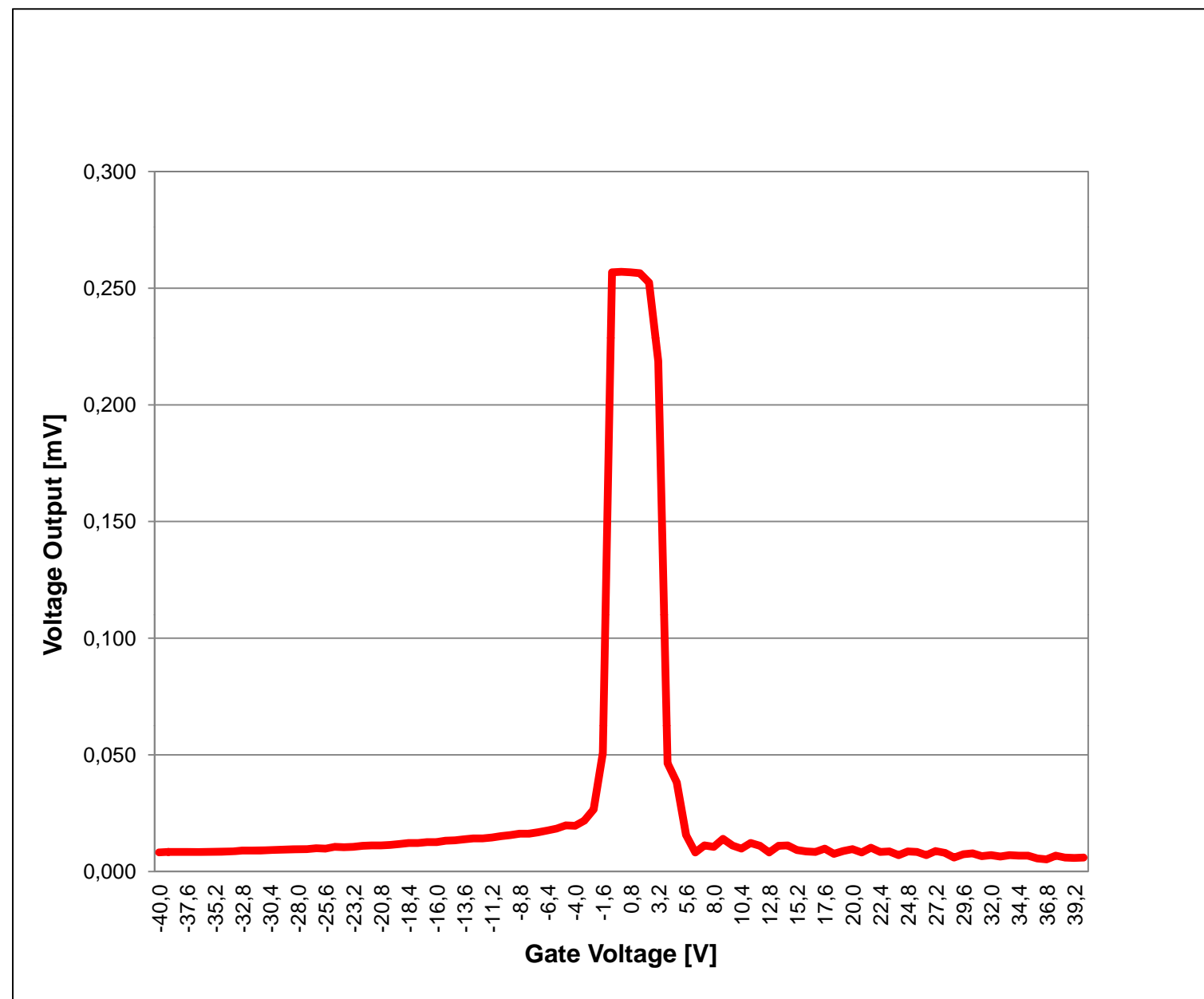
EXFOLIATED GRAPHENE PRODUCTION

- At INRiM: **mechanical exfoliation** of graphene from natural graphite flakes and deposition on Si/SiO₂ substrates (SiO₂ thickness ~ 280 nm)



SENSOR CHARACTERISATION

- The primary electrical characterization for each sensor is done by applying to the gate contact a variable voltage in the range from -40 to +40 V (DC). A **Dirac curve** is obtained.

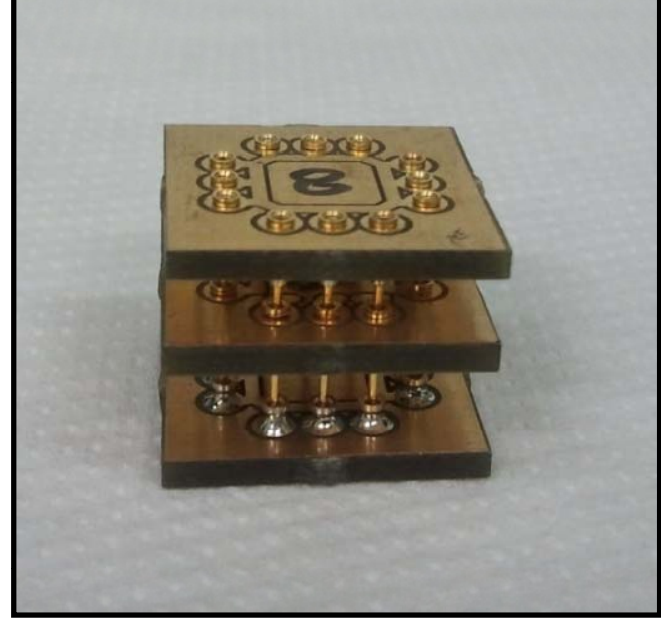
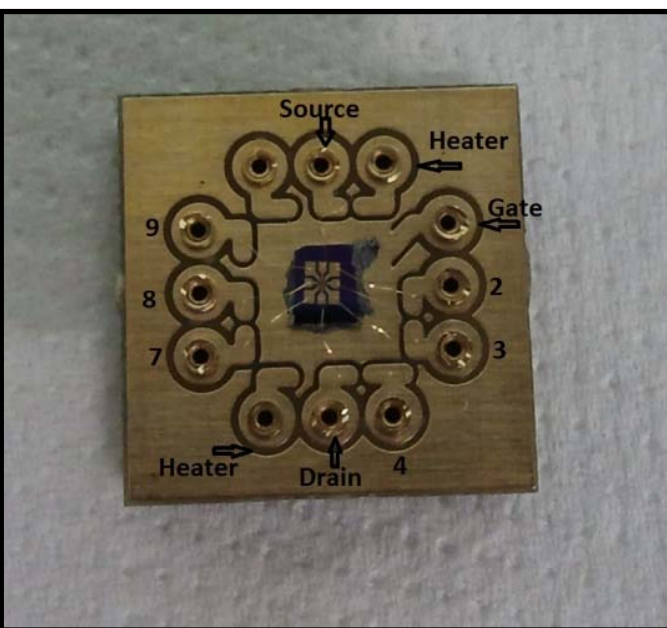


WHY GRAPHENE?

- Its outstanding charge carrier mobility implies a strong **dependence** of electrical resistivity on carrier density and, consequently, **on the electrostatic environment**.
- Graphene shows an extremely high sensitivity toward the **adsorption of gas molecules** on its surface, due to the charge transfer between gas molecules and the graphene sheet.
- Graphene is considered a promising material for producing **small-scale gas sensors** for environmental monitoring.

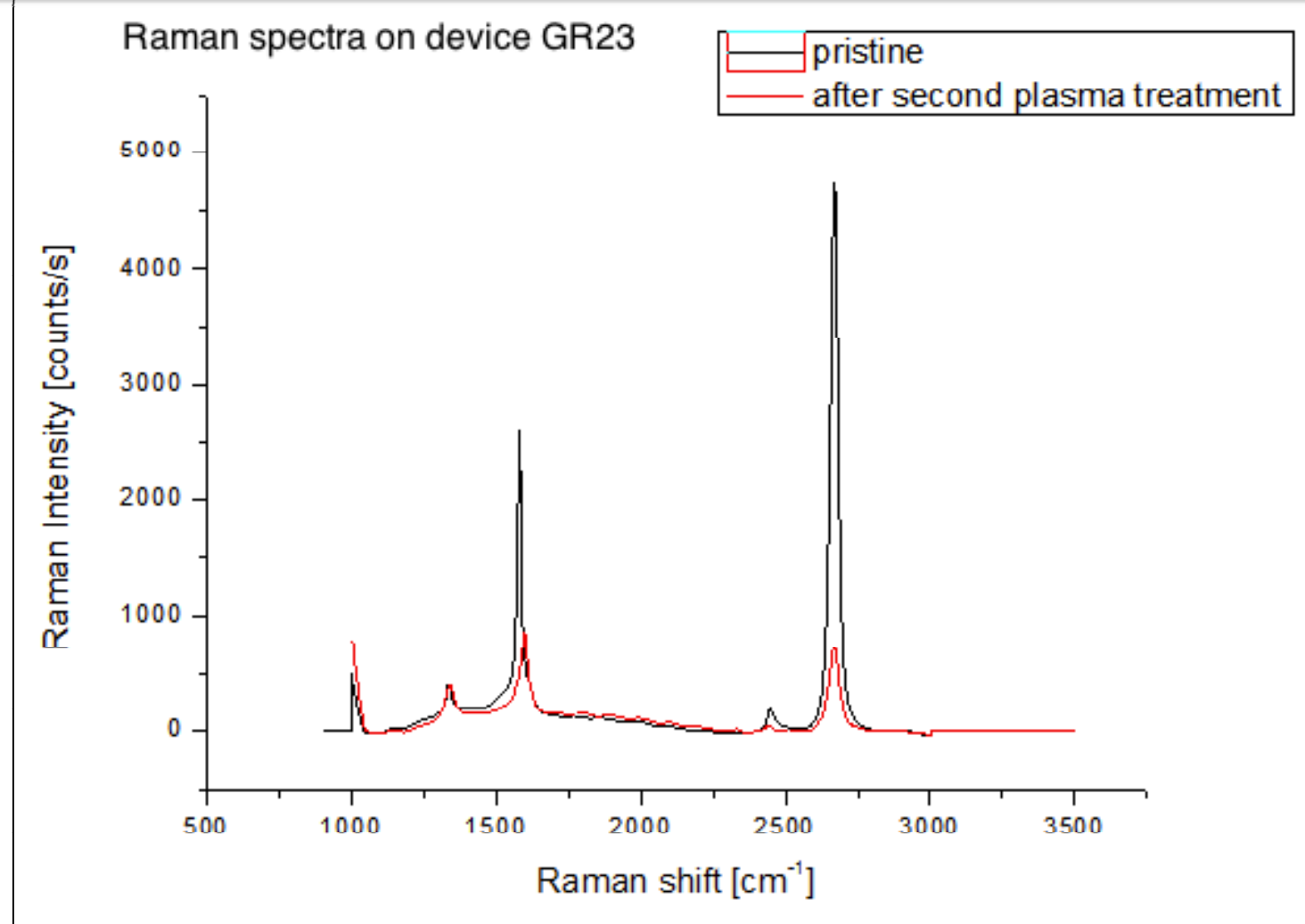
INRiM GRAPHENE-BASED SENSORS

- A sensor is prepared by means of **Electron Beam Lithography** (EBL) to make gold contacts on it.
- Then it is fixed on a proper **chip-carrier** (purchased from PTB).



GRAPHENE FUNCTIONALISATION

- Deposition of a layer of polyethylenediamine by Ar plasma **to increase sensitivity towards NO₂**.
- Raman spectra to monitor the functionalisation.



GAS MONITORING

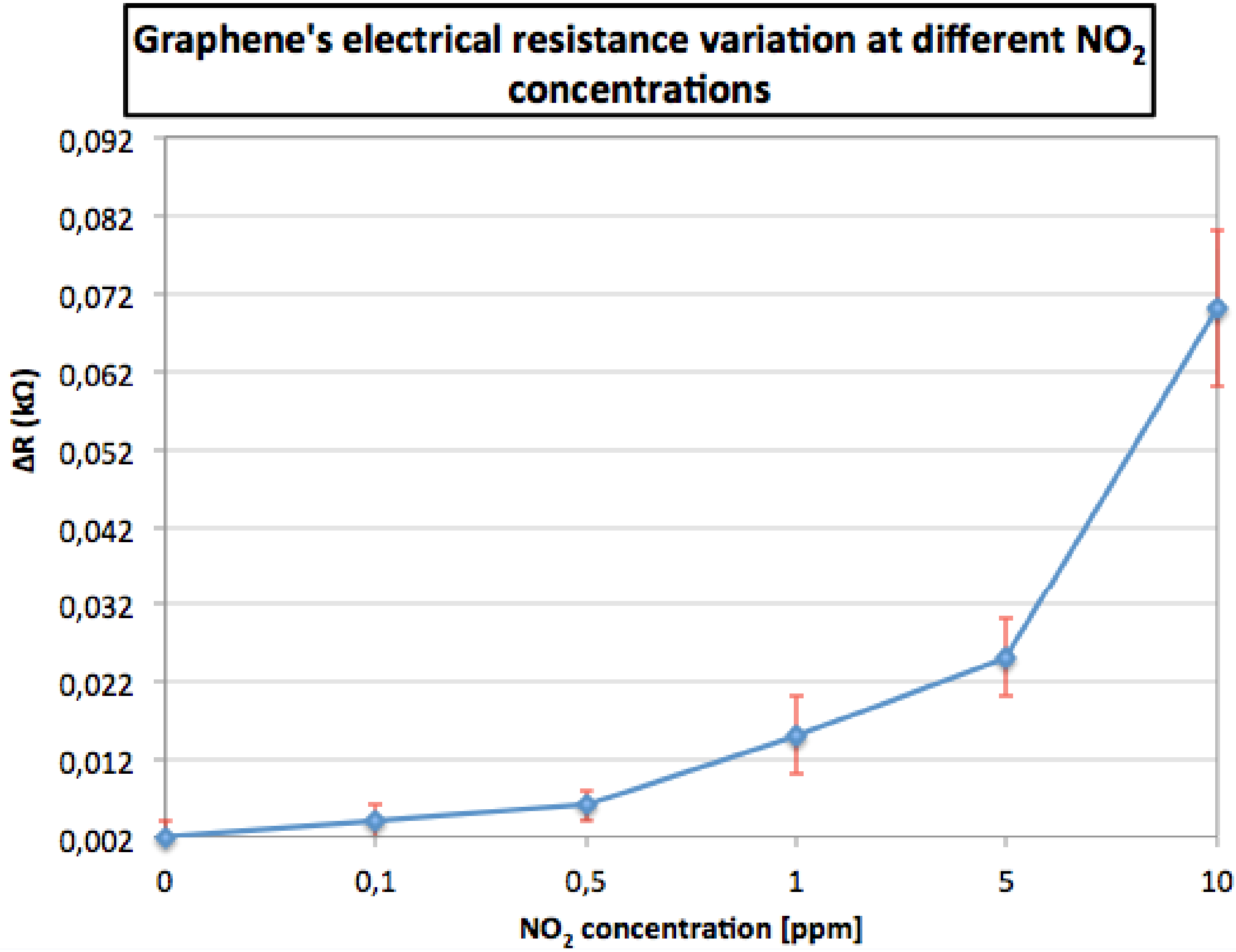
EXPERIMENTAL SETUP

- INRiM apparatus for **monitoring** graphene sensor response in the presence of gases



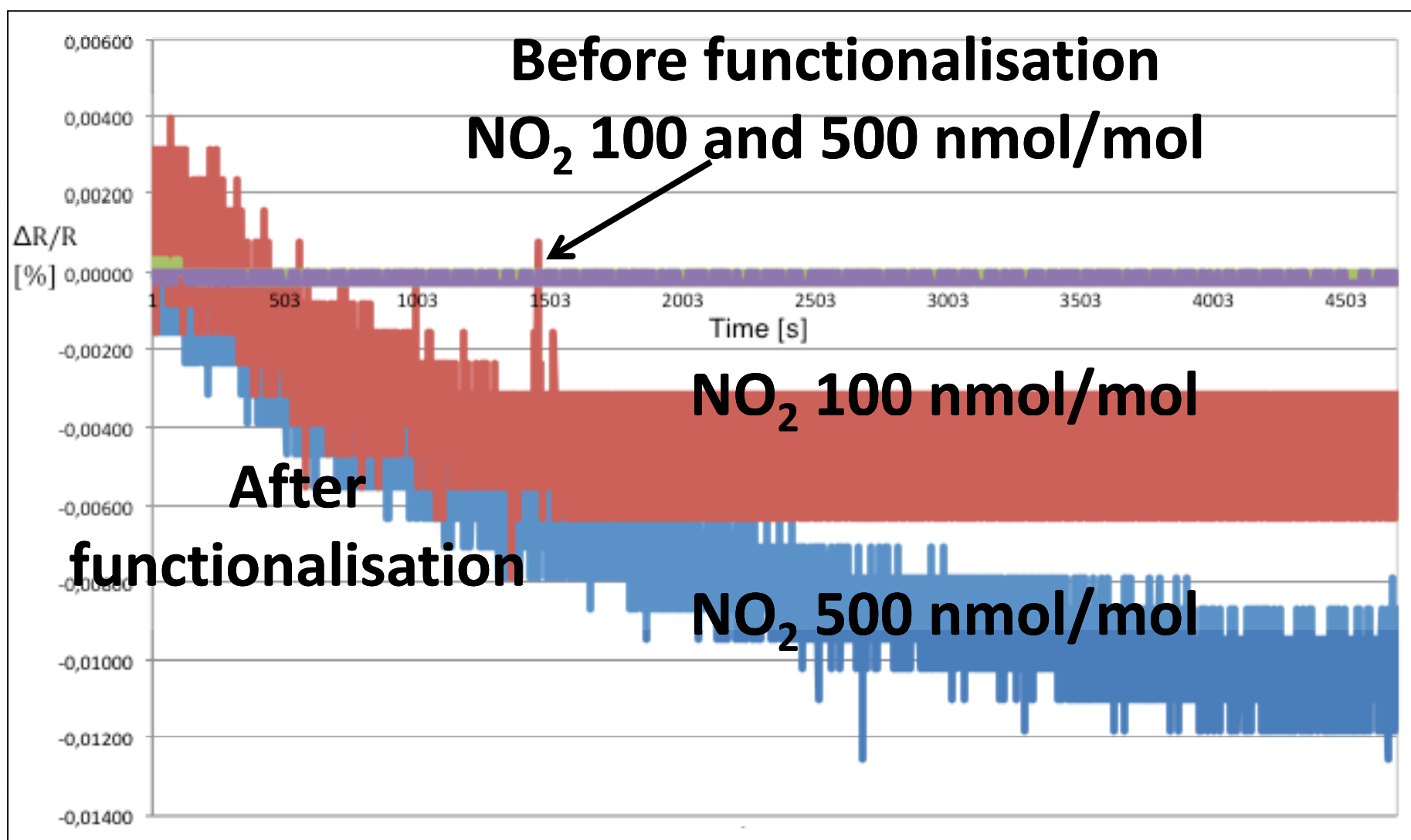
NO₂ MONITORING (100 nmol/mol-10 µmol/mol)

- Various sensings were carried out recording the **resistance variation** of the graphene sensor with time in presence of NO₂
- NO₂ concentration in the range 100 nmol/mol – 10 µmol/mol



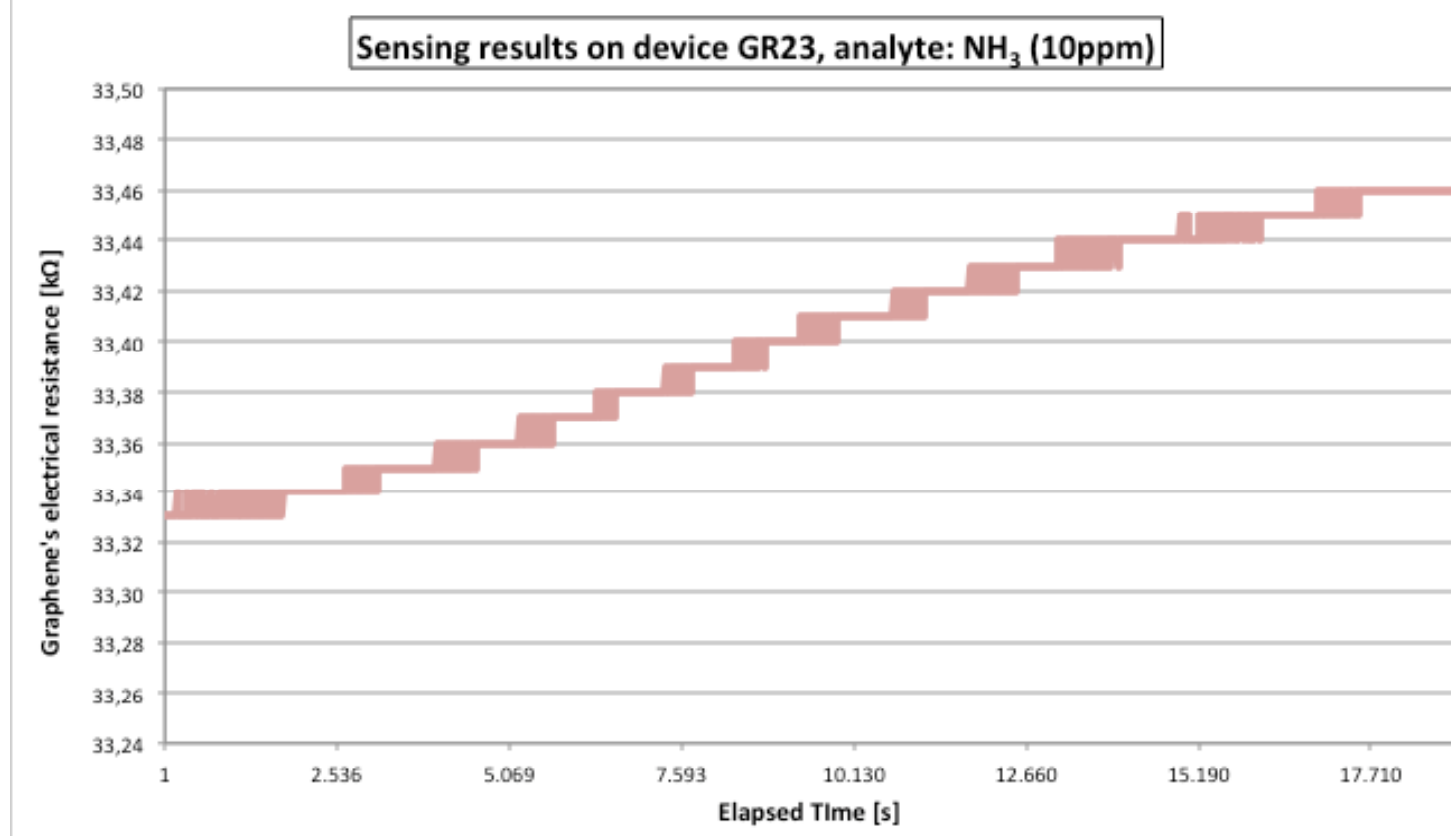
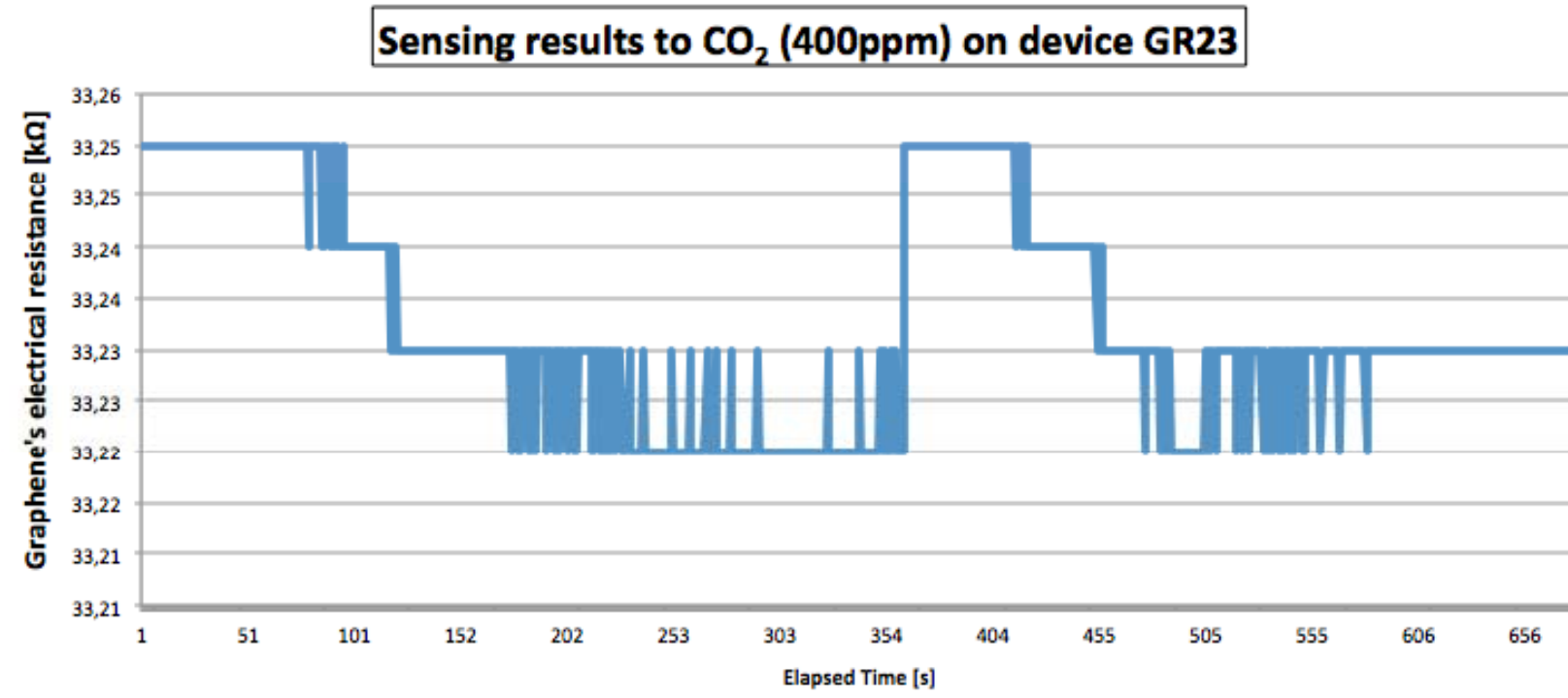
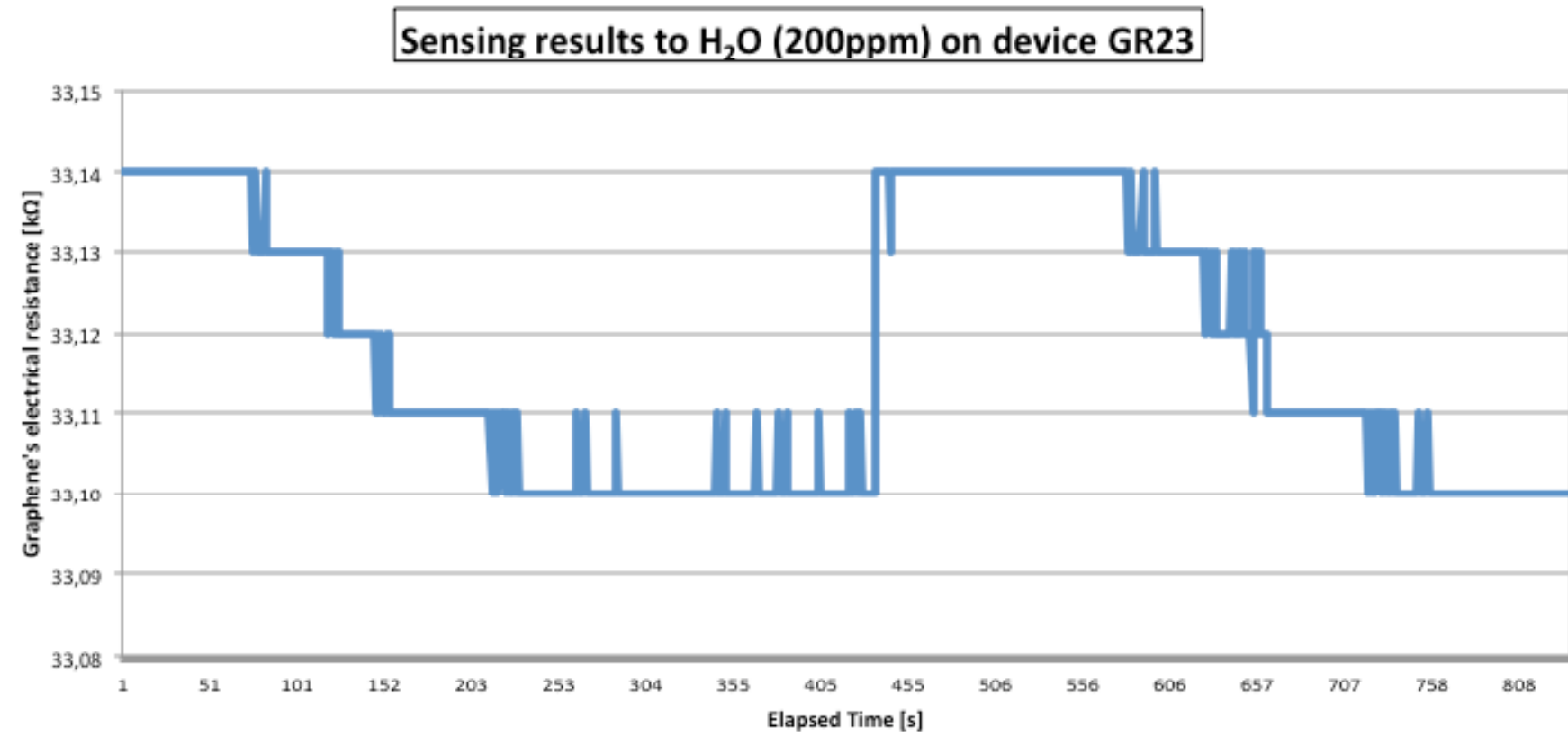
NO₂ MONITORING AFTER FUNCTIONALISATION

- Functionalisation of graphene with polyethylenediamine results in **increased sensitivity**.
- Relative resistance variation of the sensor with time at NO₂ concentration of 100 nmol/mol and 500 nmol/mol



INTERFERING SPECIES

- The variation of graphene sensor resistance was monitored in presence of possible **interfering gases** present in environmental air:
- H₂O (200 µmol/mol)
- CO₂ (400 µmol/mol)
- NH₃ (100 µmol/mol)



- NH₃, due to its different electronegativity, results in an **increase in resistance** during sensing.

- Detail with the allocation of the **sensor inside the chamber**, closed during sensing.

