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A resistive soot sensor for mass quantification through a correlation between conductance and soot mass loading

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Nuclear safety

- Fire : one of the most hazardous risks in nuclear facilities
- Assess the consequences of particle emissions on containment devices, such as High Efficiency Particulate Air (HEPA) filters

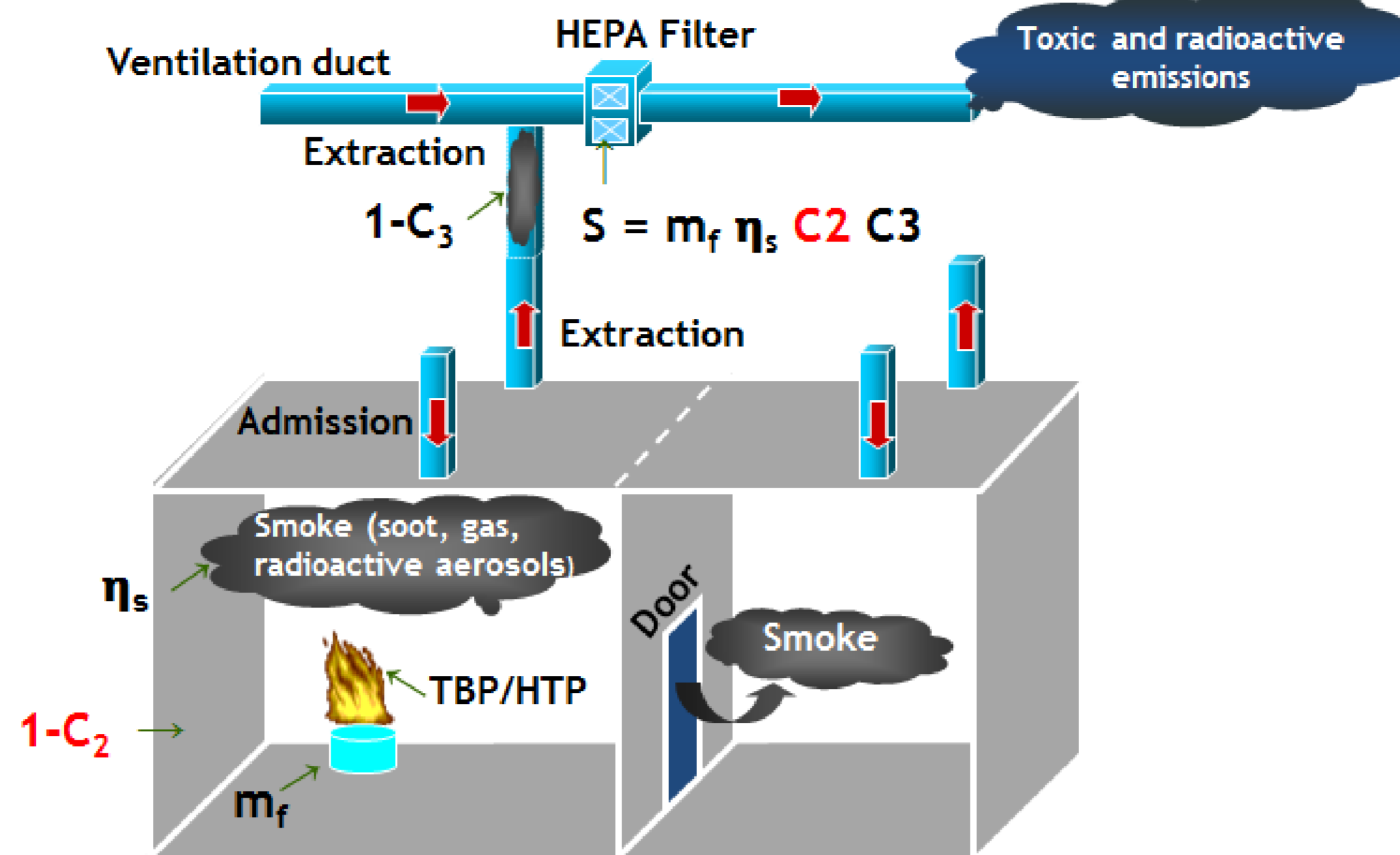
Principal consequences of a fire



- Radioactive aerosol release,
- Production of a large amount of soot,
- Clogging of HEPA Filters [1],
- Modification of pressure conditions in the facility,

- ➔ Lack of experimental and quantitative data on soot deposition during a fire,
- ➔ No real time sensor to provide soot deposited fraction

Context and aim of the study



S : mass of soot arriving on HEPA filters (kg),
 m_f : amount of consumed fuel (kg),
 η_s : soot emission factor (kg of soot per kg of consumed fuel),
 $1-C_2$: fraction of soot deposited on the walls(-),
 $1-C_3$: fraction of soot deposited in the ventilation ducts (-),

Deposit Characteristics

Real scale fire tests

- Relatively homogeneous deposit except on the ceiling
- Walls deposition fraction from **25 to 40 %**
- Deposit flux : **2 to 42 mg/m²/min**
- Deposit rate:

Surface of analysis	90x90 mm	3.5x3.5 mm
Deposit rate	14 to 340 $\mu\text{g}/\text{min}$	0.2 to 5 $\mu\text{g}/\text{min}$

- Deposit thickness from **5 to 8 mm**
- ➔ Regenerative sensor to avoid saturation

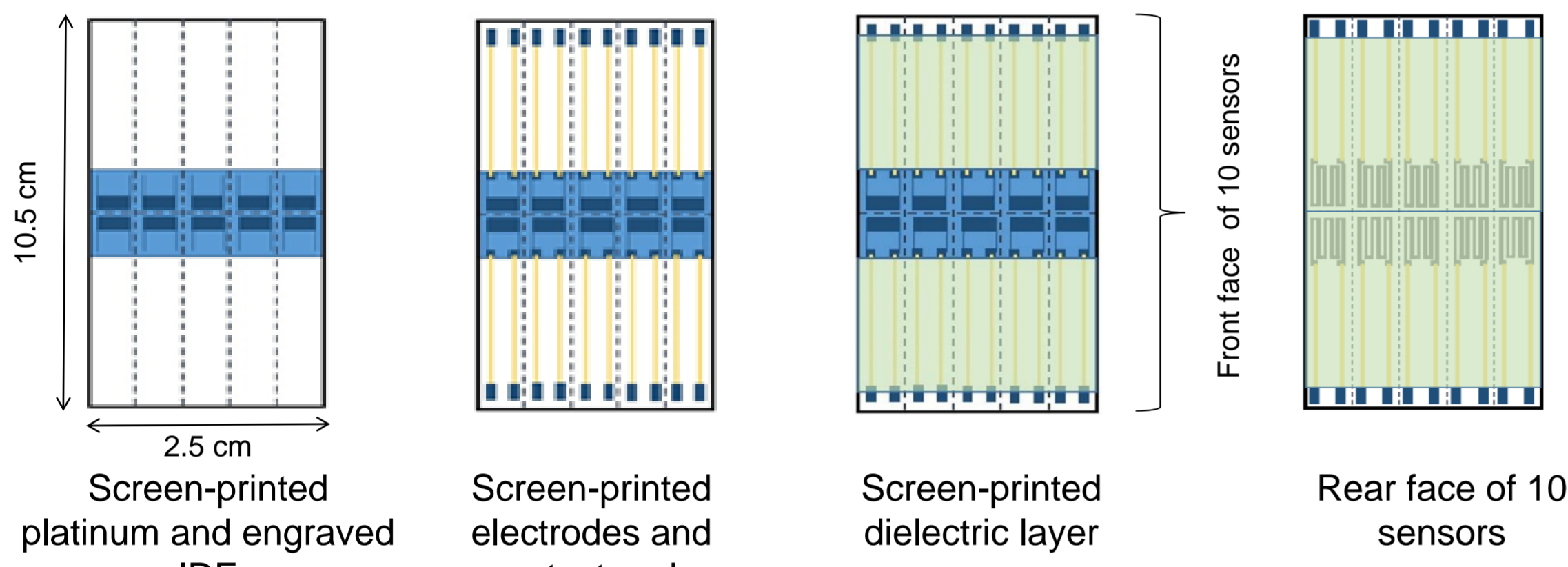
Aim of the study

- Polarization voltage influence on the deposited mass
- Correlation of the soot mass loading to the sensor electrical response

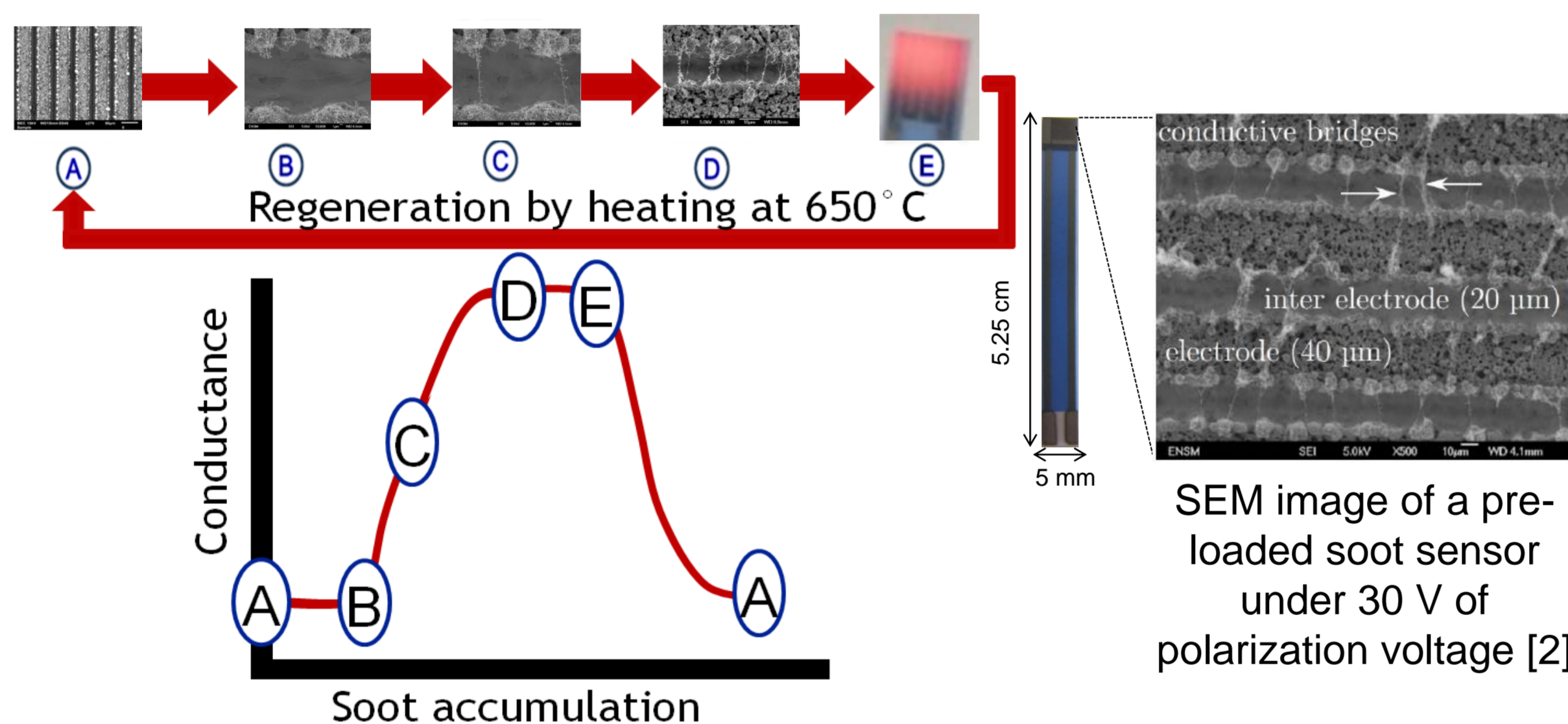
Sensor calibration : electrical response

Resistive soot sensor

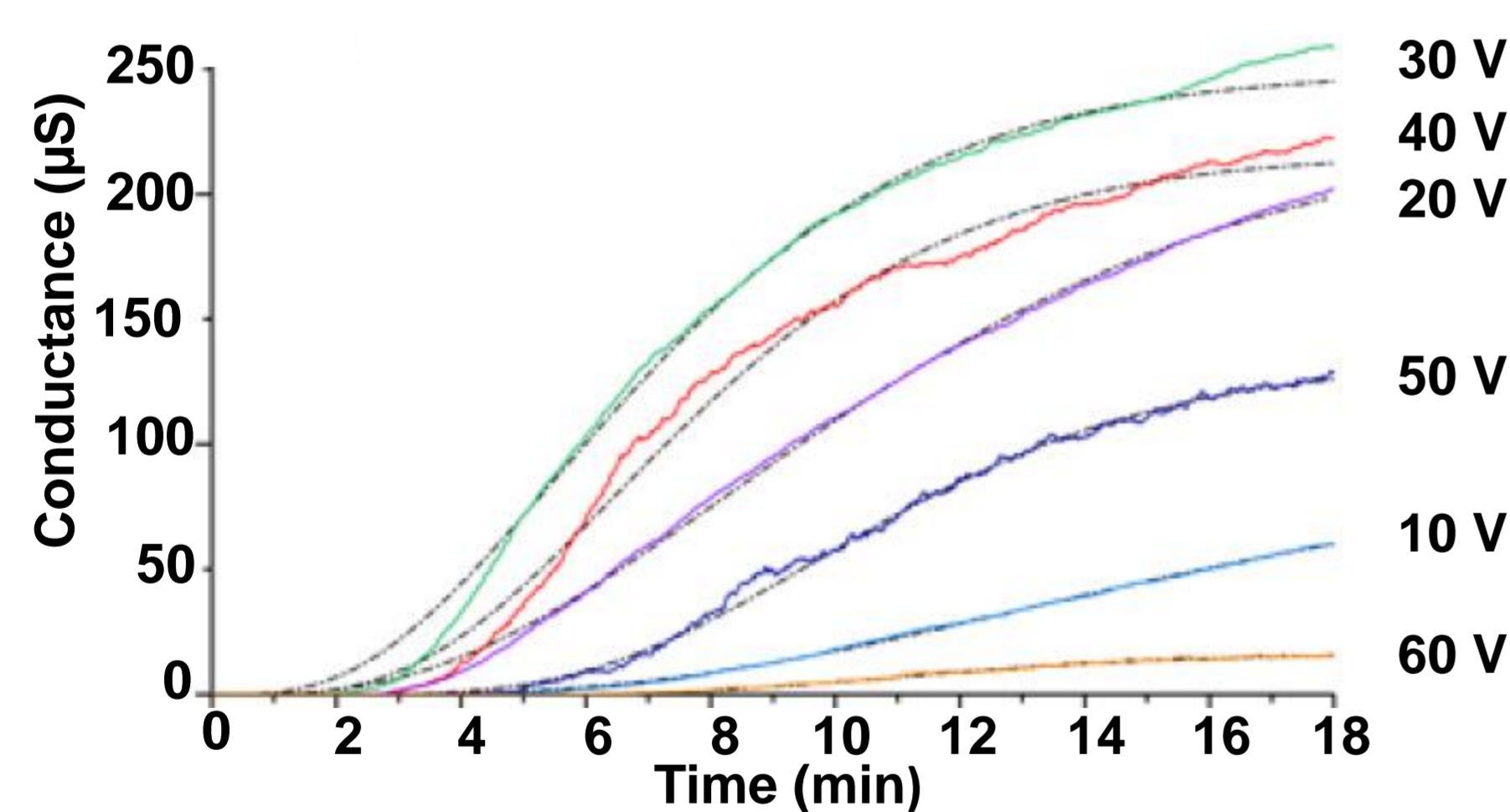
Sensor manufacturing



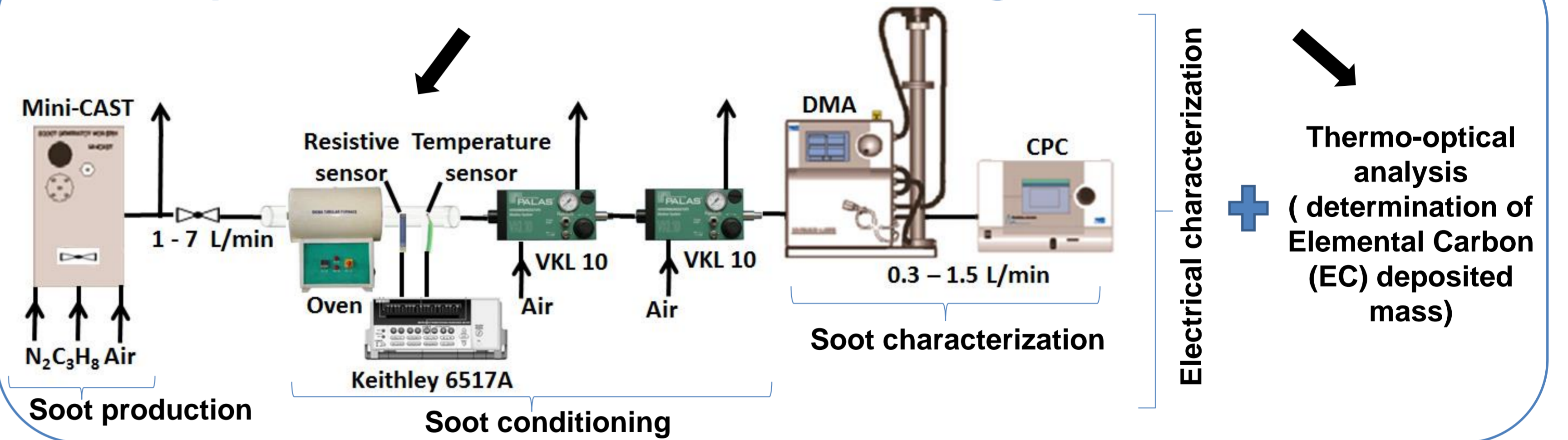
Sensor principle



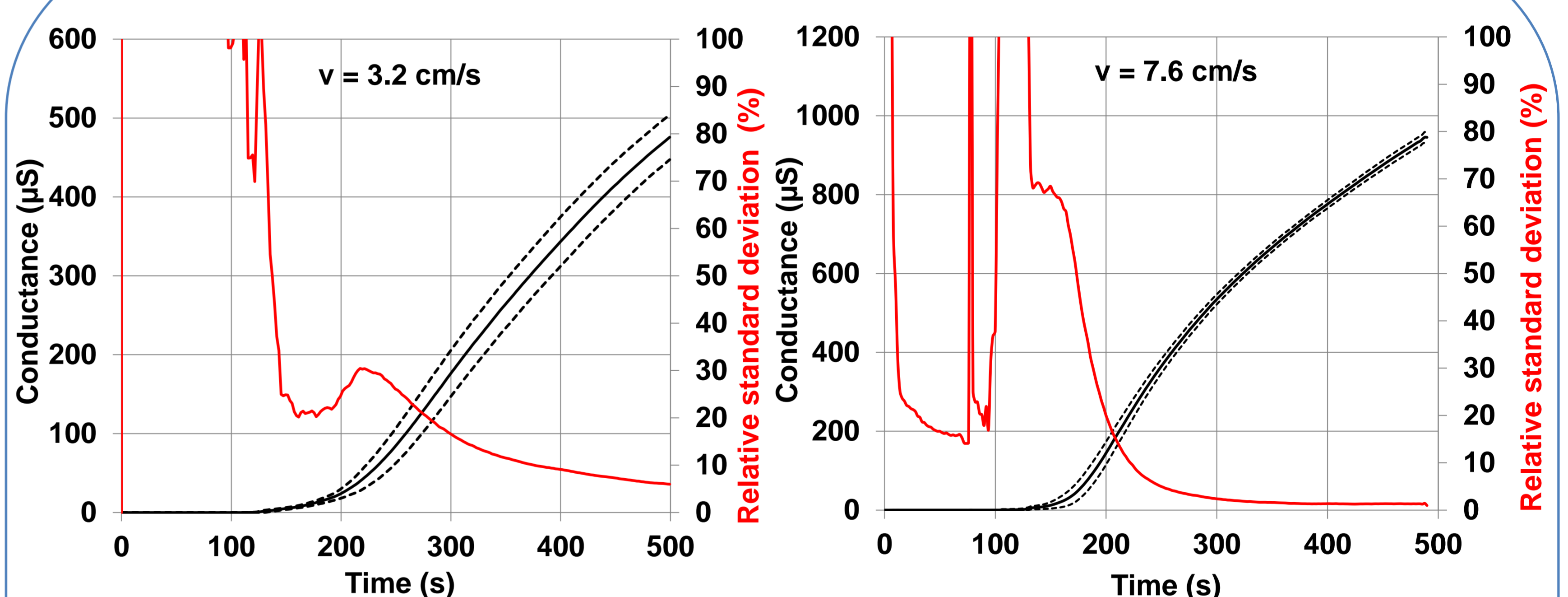
Influence of the polarization voltage on the sensor response [2]



Experimental correlation of mass loading to conductance



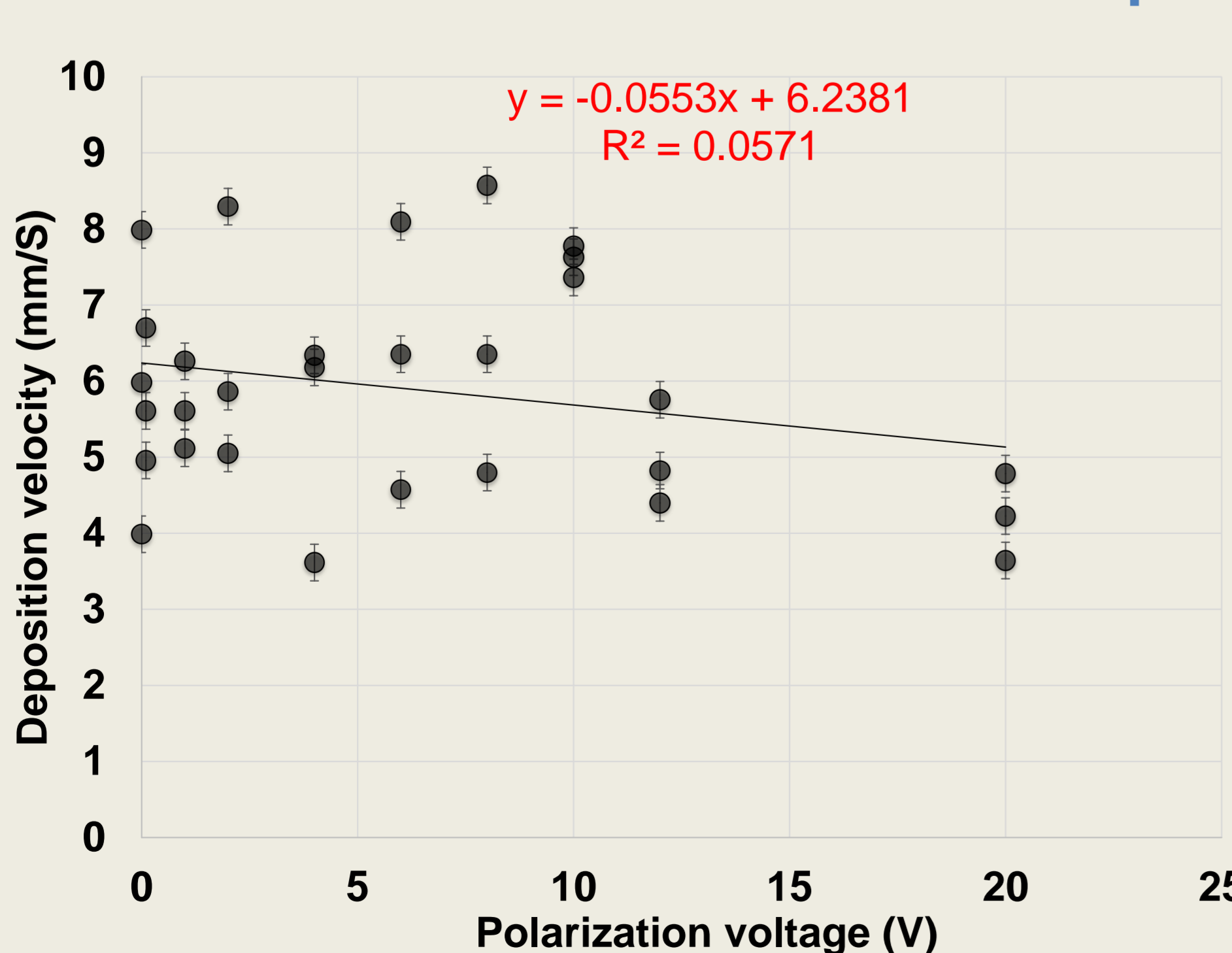
Electrical measurements



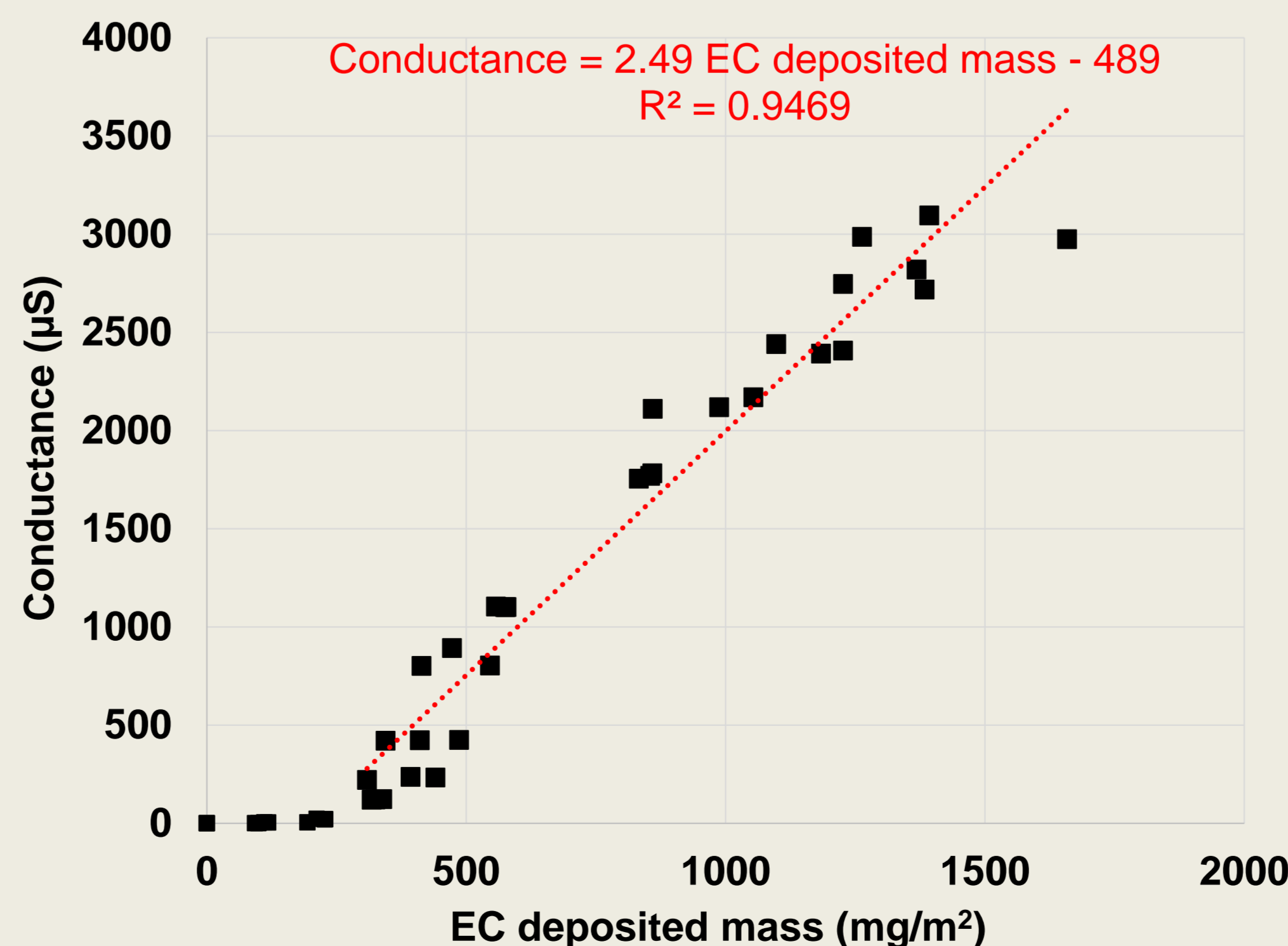
Polarization voltage (V)	Flow Velocity (cm/s)	Particule's median diameter (nm)	Concentration (#/cm ³)	Mean percolation Time (s)	Mean reached Conductance at 500 s (μS)
10	3.2	200 (± 1)	9.10 ⁶ (± 10%)	132 (± 16)	476 (± 8)
10	7.6	166 (± 0.5)	1.5.10 ⁷ (± 3%)	129 (± 10)	945 (± 10)

➔ A repeatable sensor response that depends on particles' morphology and concentration

Towards real-time quantification : influence of the polarization voltage on deposited mass



➔ Same deposition velocity under low polarization voltage (0 to 20 V)



➔ Mass to conductance correlation at a polarization voltage of 10 V

Conclusions and perspectives

Conclusions

- No influence of polarization voltage lower than 20 V on deposited mass
- Soot mass loading to conductance correlation

Perspectives

- Definition of a measurement strategy to determine the required number of sensors to quantify the deposited mass in a facility during a fire
- Identification of the most relevant polarization voltage
- Application of the correlation to realistic soot particles (TBP/HTP)