UNIMORE
UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

ICHTHYS

ICHTHYS

OptImization of novel value CHains for fish and seafood by developing an integraTed sustainable approacH for improved qualitY, safety and waSte reduction

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24/05/2023
Sarajevo, Bosnia and Herzegovina

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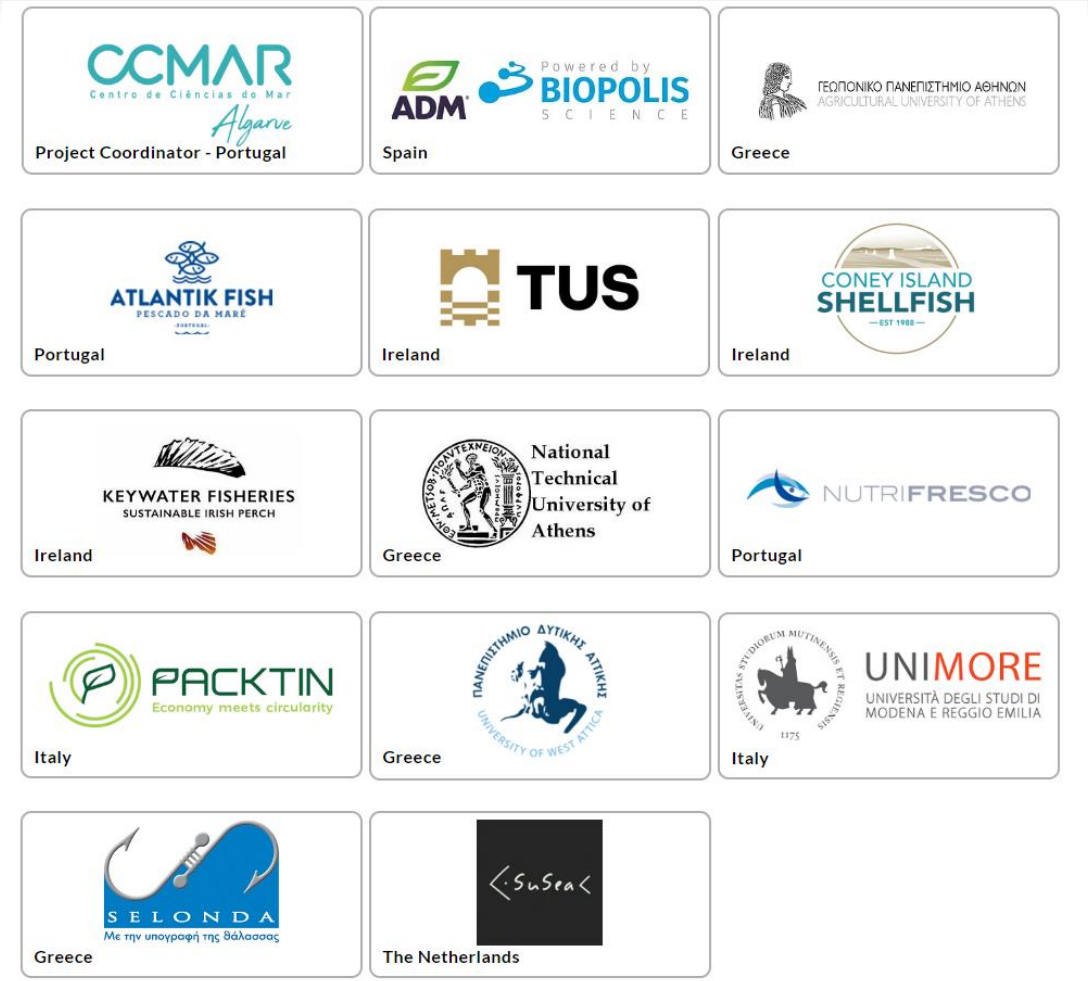
ICHTHYS is a multidisciplinary, a cross-sectorial project that aims to optimize novel value-chains for **fish and seafood products** to reach the EU market and to develop an **integrated sustainable approach** to improve **quality** and **reduce product loss** during the supply chain.



ICHTHYS

Extend shelf life (reaching a two to three-fold increase) of fish and shellfish products and reduce food waste

Develop innovative and safe seafood products of high and desired sensor characteristics

Develop active and intelligent packaging for seafood products

Establish the basis of nonthermal processing for seafood products

Improve safety of seafood consumption related to control of pathogens, toxins and allergenic substances

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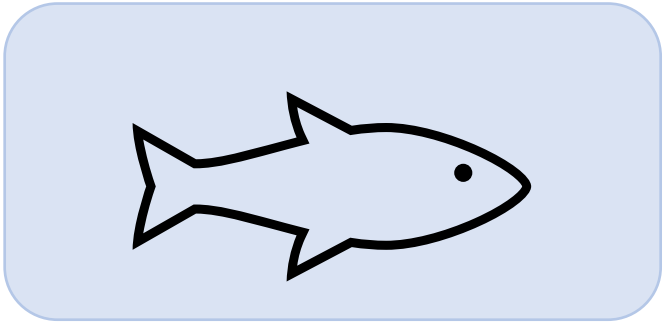
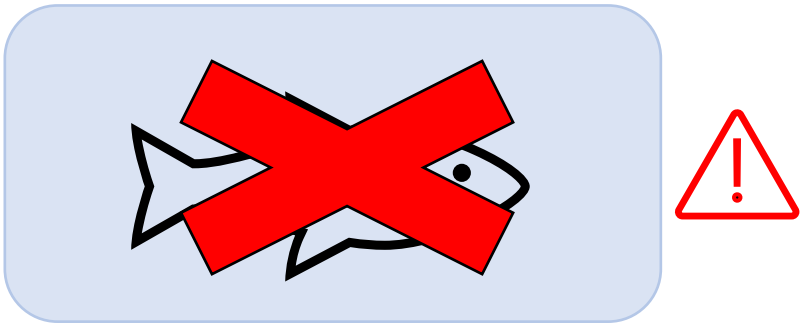
ICHTHYS

Monitor the fish **freshness** along the **cold chain** and on the **shelf** by detecting specific markers.

Fresh



Not fresh,
exposed to air or to high temperatures



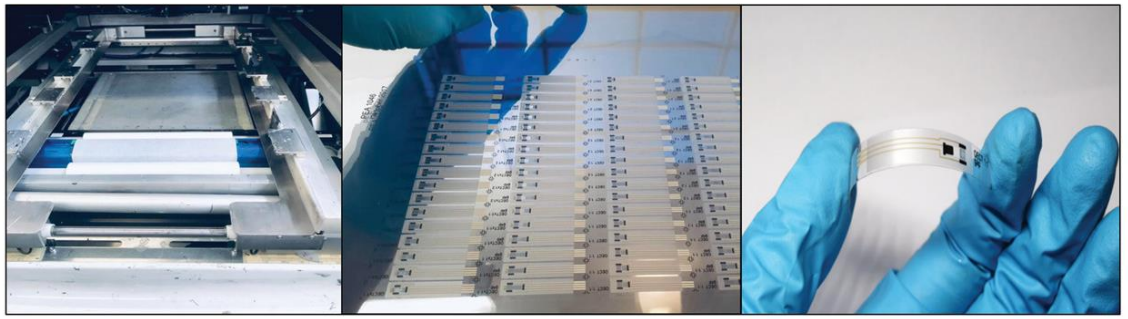
Integrated devices to detect:

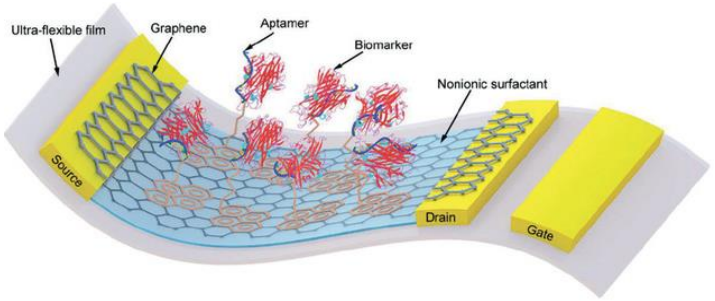
- **Chemicals** released upon food degradation
- **Temperature** variations, above a threshold
- **Packaging** leaks

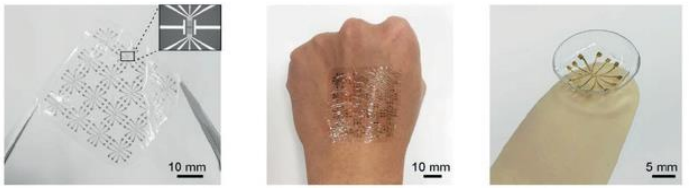
Transistor based biosensors

Materials strategies for **freshness** biosensors based on **graphene** and **organic electronics devices.**

- Biocompatible
- Healtchare applications
- Portable
- Flexible
- Cost-effective
- Easy-to-use
- Require low amount of sample
- Require low-voltages
- Label-free

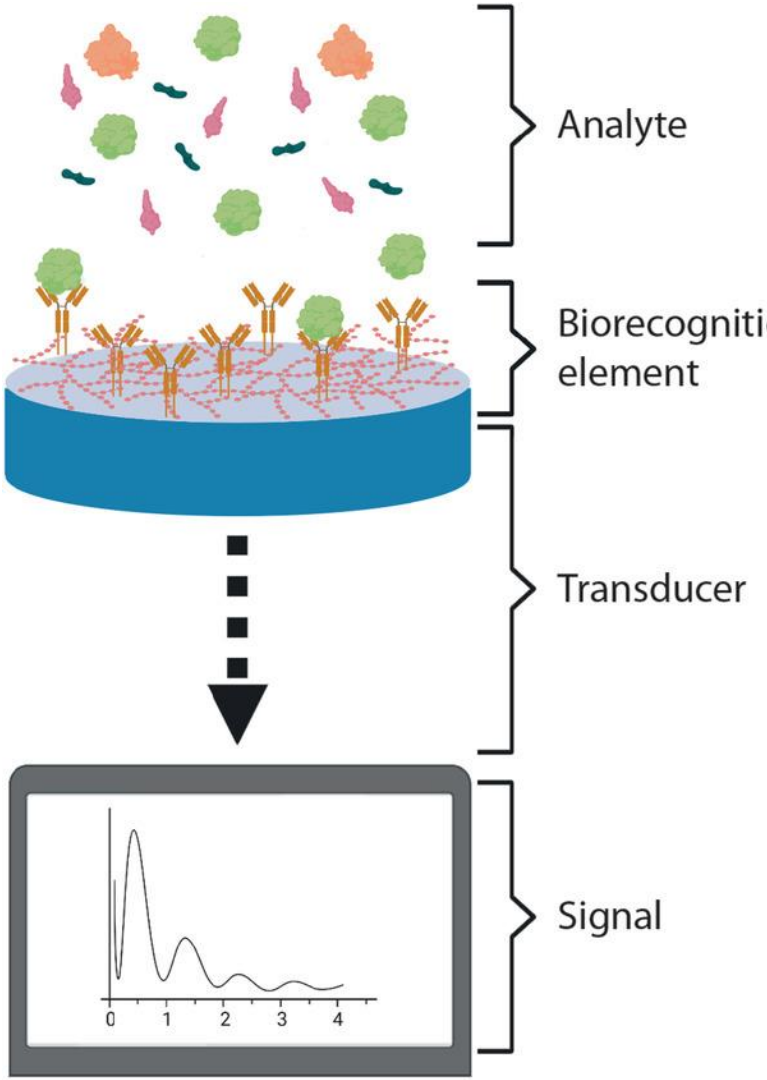


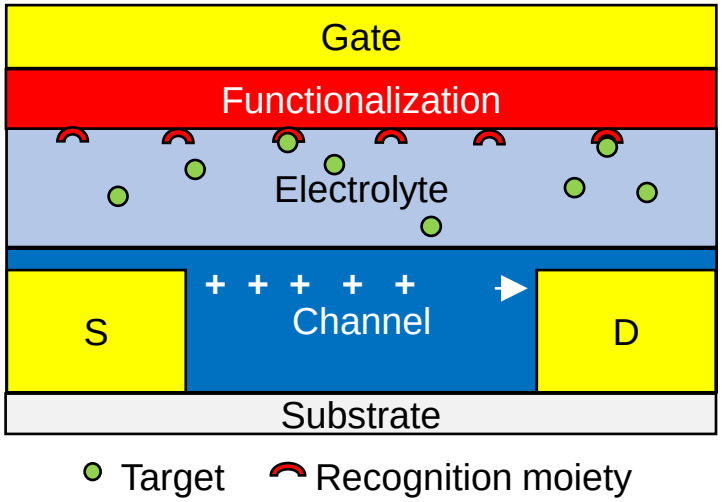




Burtscher, B.; Manco Urbina, P. A.; Diacci, C.; et al. *Advanced Healthcare Materials,* **2021**

Transistor based biosensors





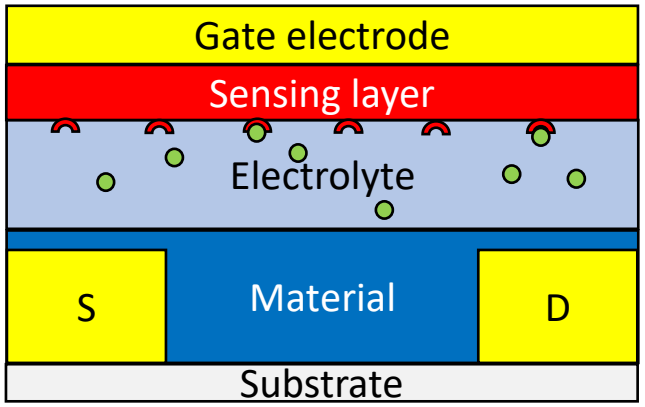
- Actual methods require long time, high costs and complex instruments
- Sensors based on **organic electronics and graphene**: easy to use, cost-effective, high selectivity and sensibility, can be fabricated on flexible substrates.

Burtscher, B.; Manco Urbina, P. A.; Diacci, C.; et al. *Advanced Healthcare Materials,* **2021**

Transistor based biosensors

Food freshness sensor targets

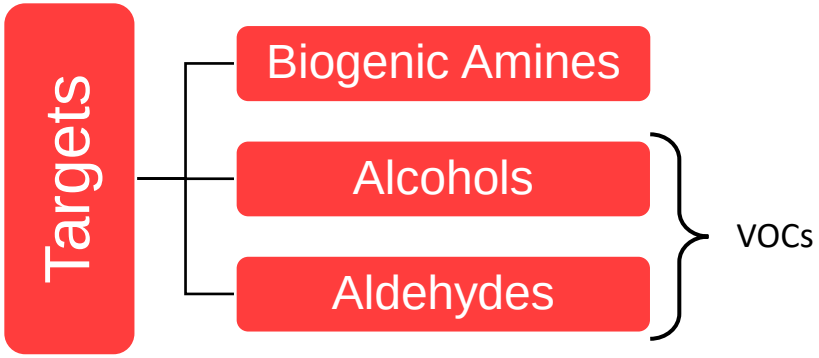
Electrolyte-Gated Transistors



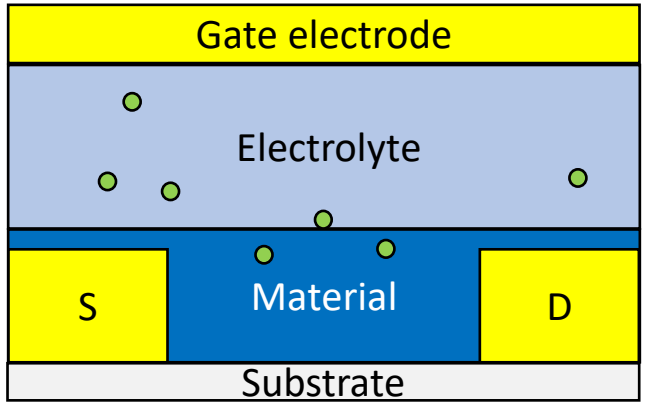
- The recognition event that takes place on **gate electrode**
- The device generates an analyte concentration-dependent multiparametric response.

Transistor based biosensors

Food freshness sensor targets

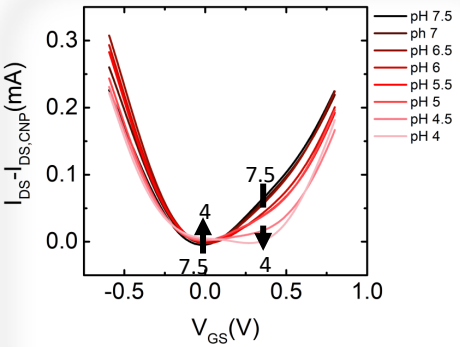


Electrolyte-Gated Transistors

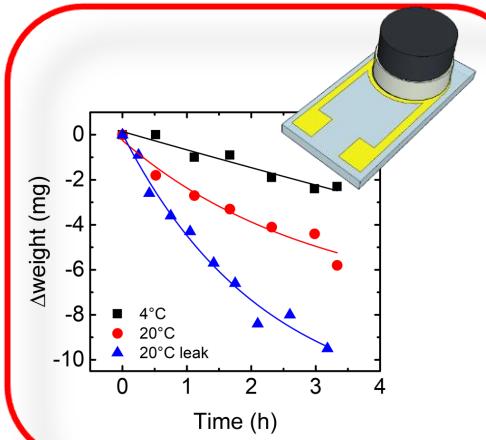


- The recognition event that takes place on the **active material**
- The device generates an analyte concentration-dependent multiparametric response.

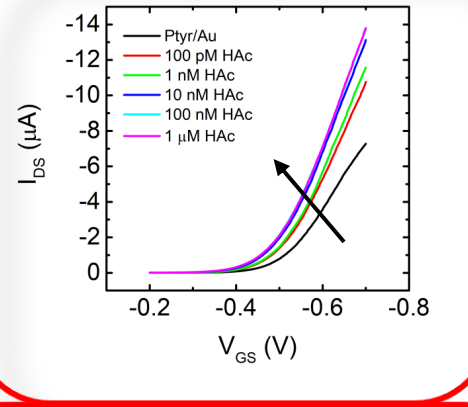
Sensors for Food Freshness



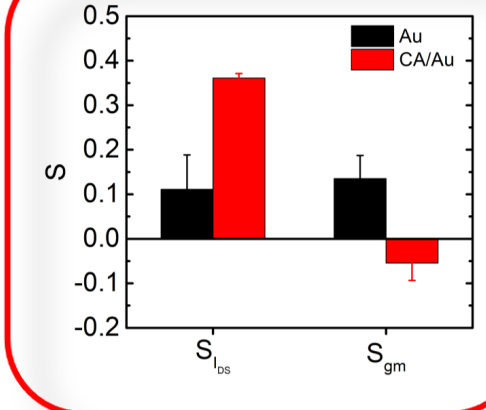
pH Sensor



Temperature/Leakage Sensor



VOCs Sensor

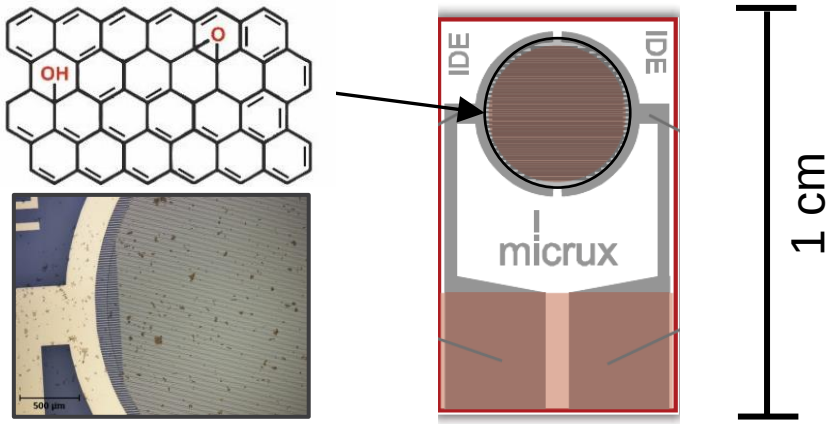


Biogenic Amine Sensor

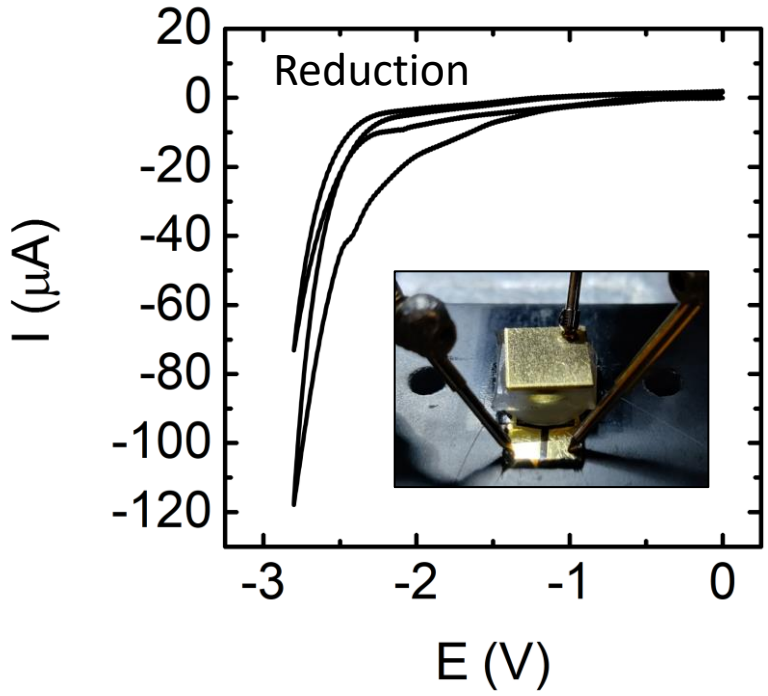
rGO-Electrolyte Gate Transistors

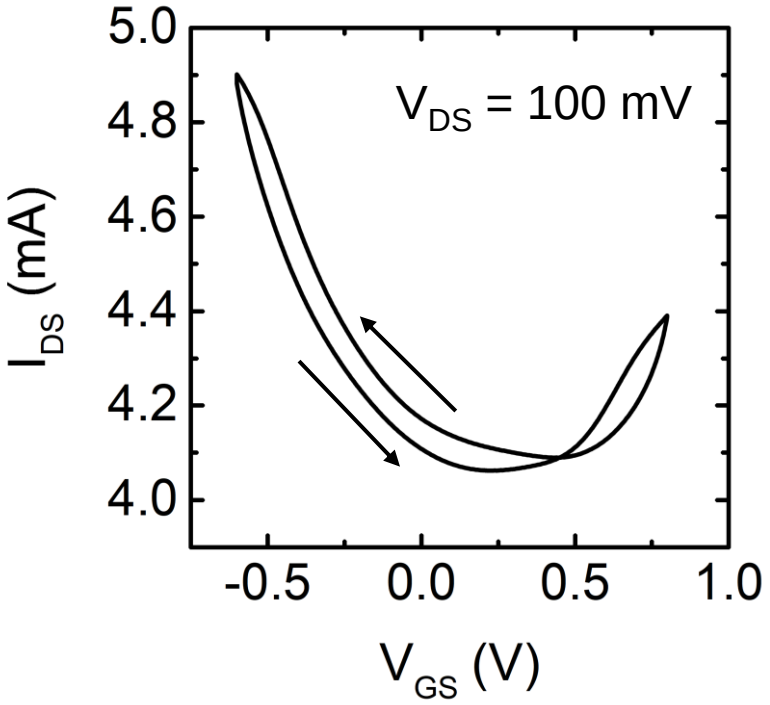
- Processing in acquous solutions, without toxic solvents.

Reduced Graphene Oxide



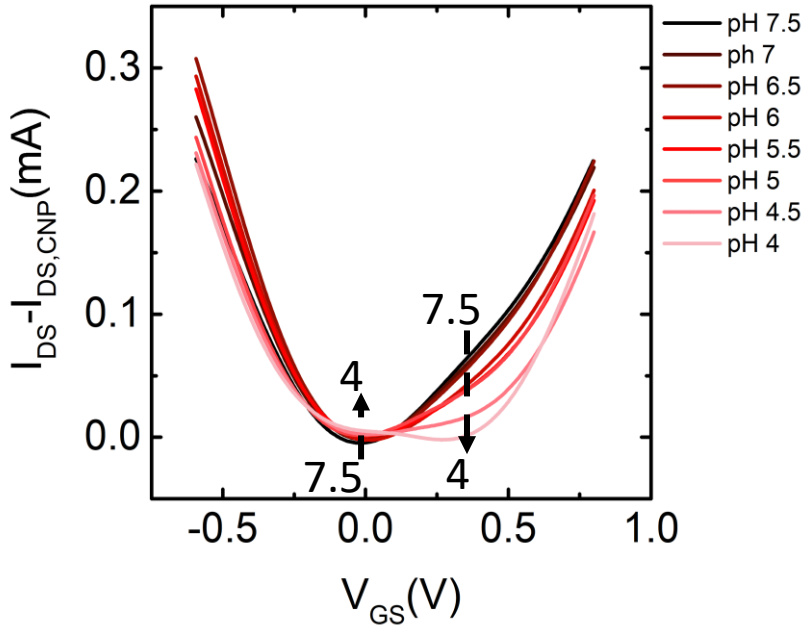
IDE with GO short-circuited vs Au plate

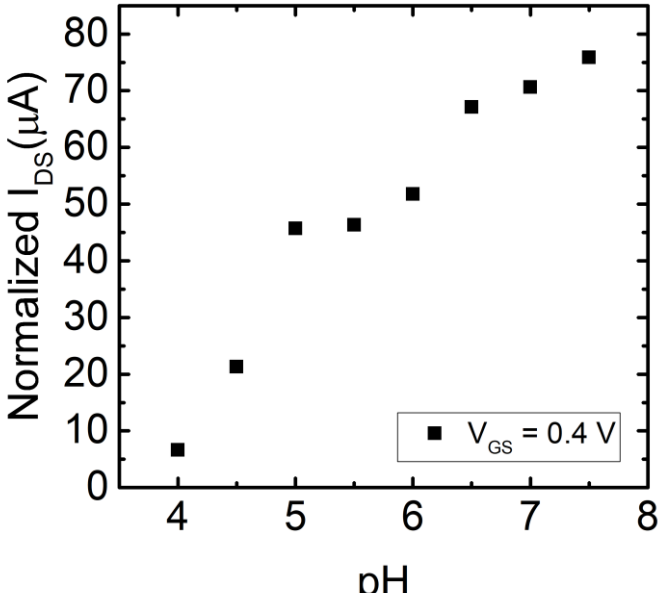


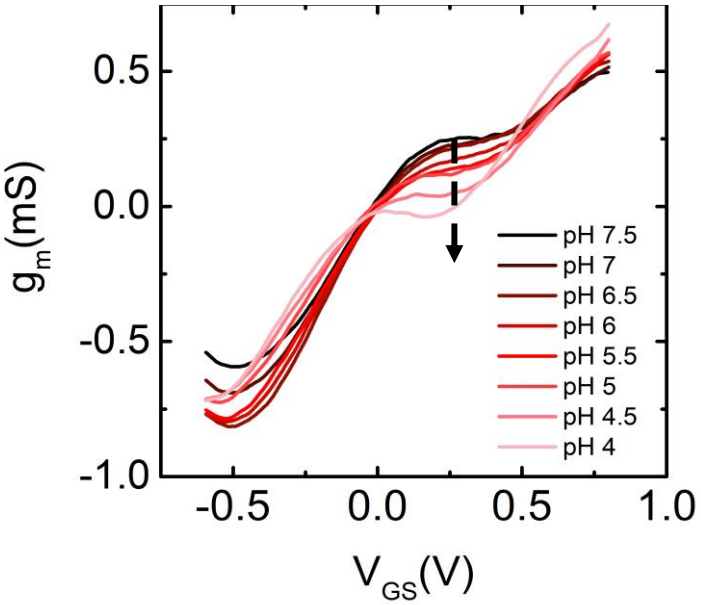


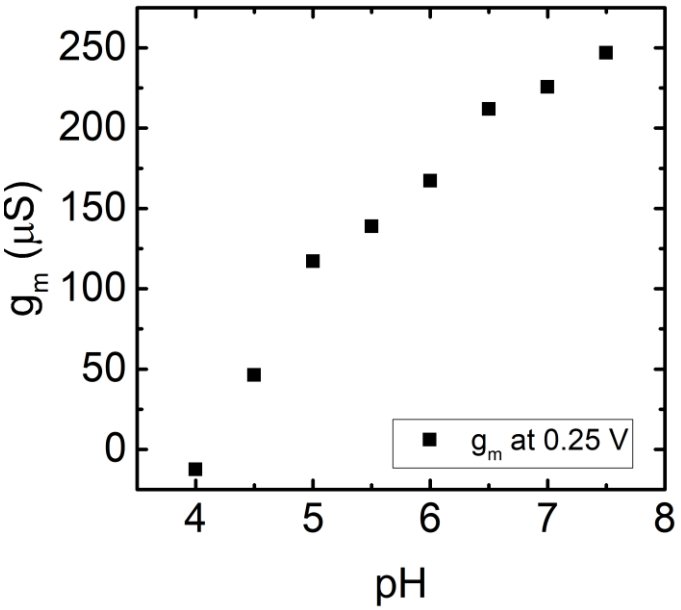
OFET-based biosensor for package integrity

pH (acidification due to CO_2 increase or alkalinization due to amines)





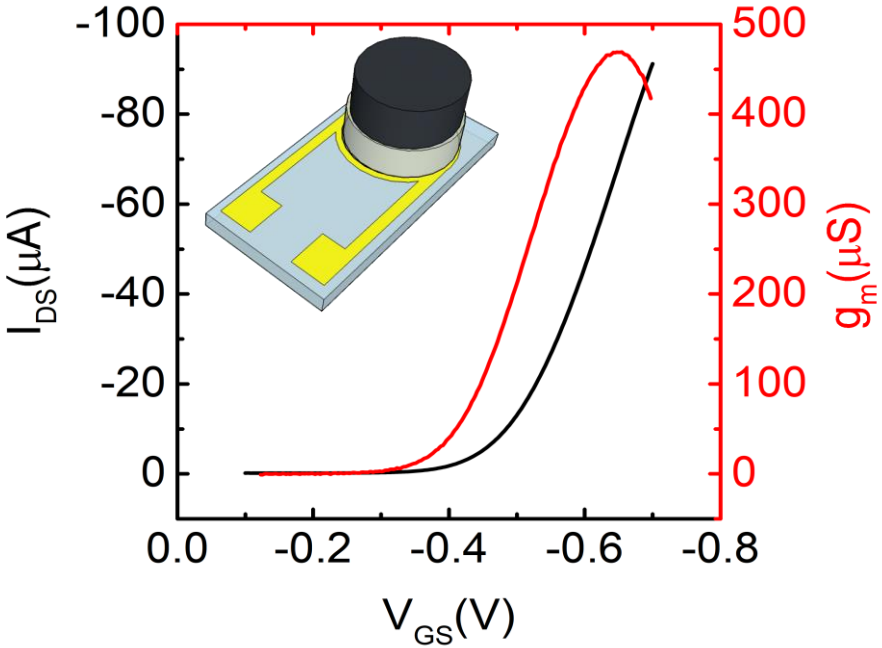


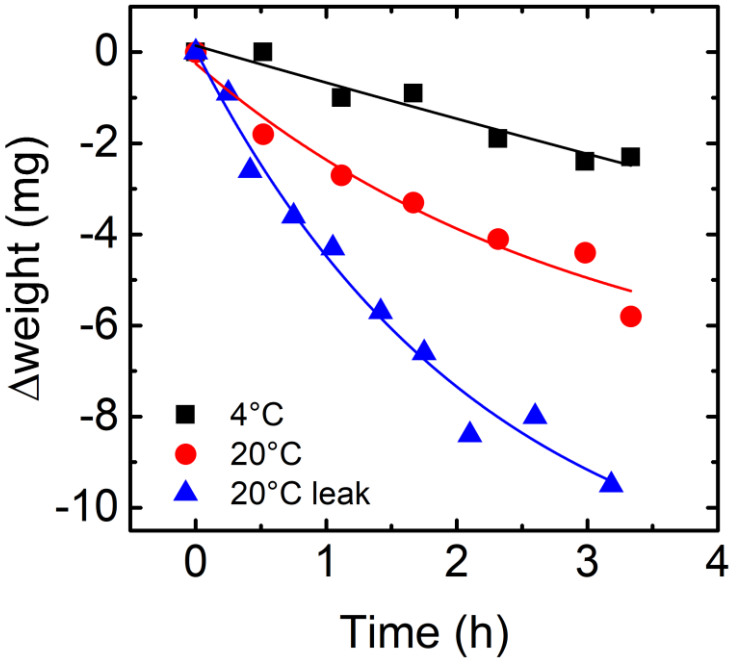


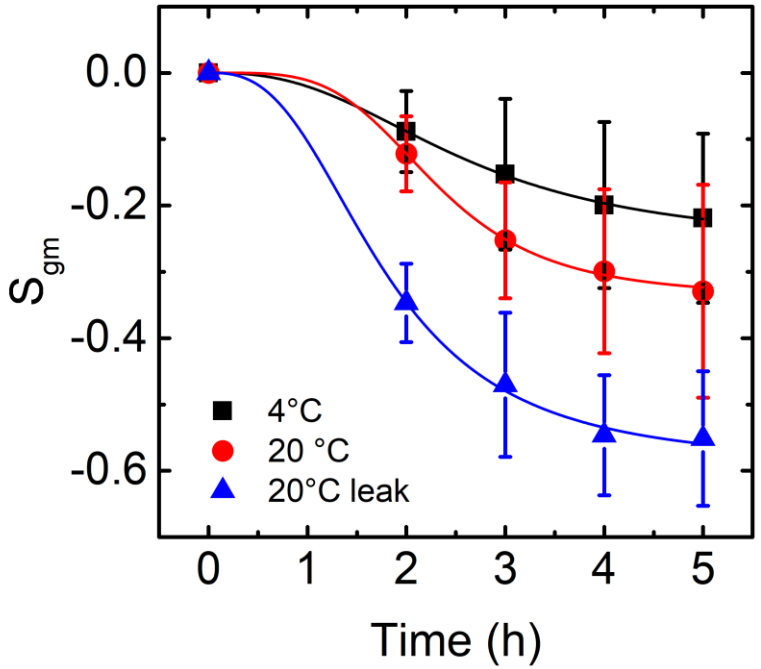
Agar electrolyte

- Solid Electroyte: 2% agar in 1X PBS
- Channel material: DPP-DTT

rGO + PEDOT:PSS hydrogel



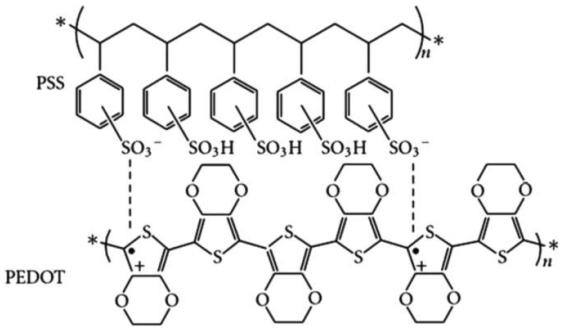


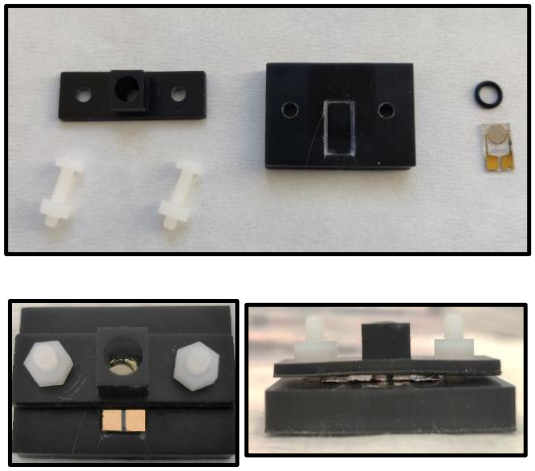


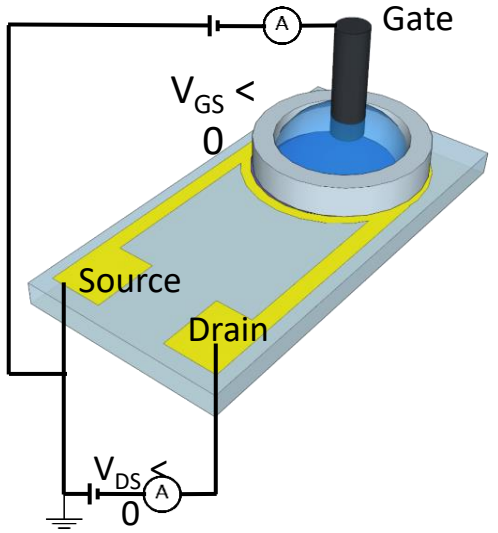
Biogenic amines sensor

Tyramine sensor: multiple amines

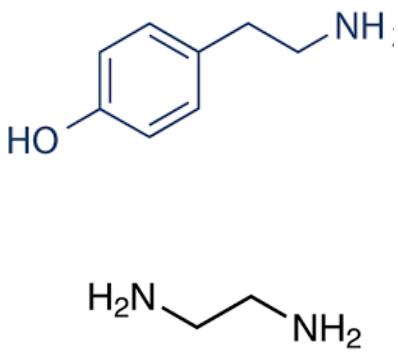
PEDOT:PSS

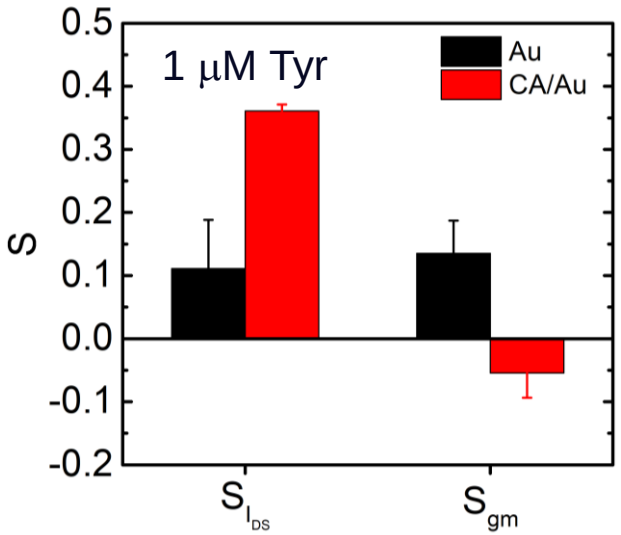


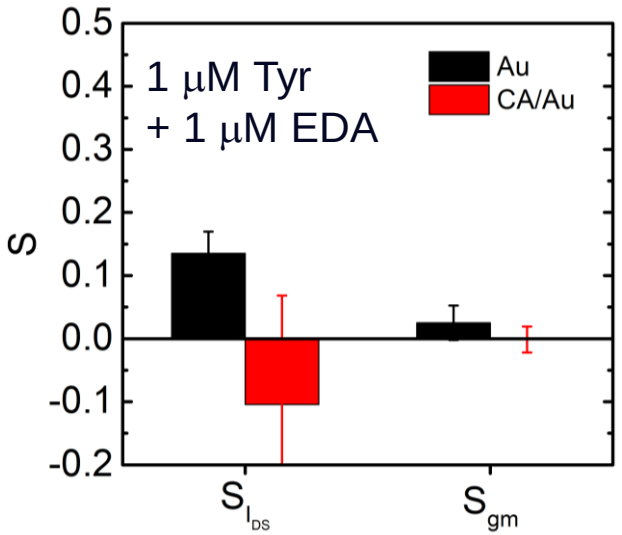




- Multi parametric response for biogenic amines detection and discrimination

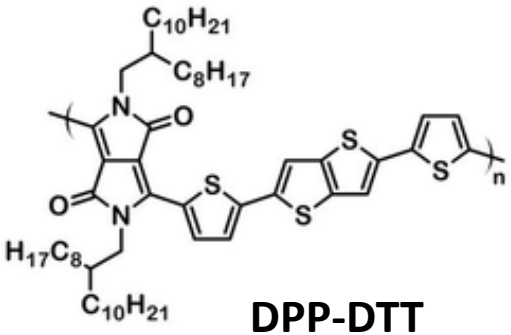




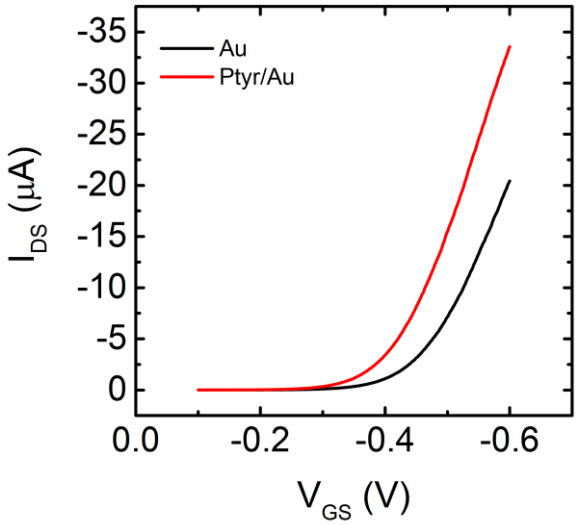


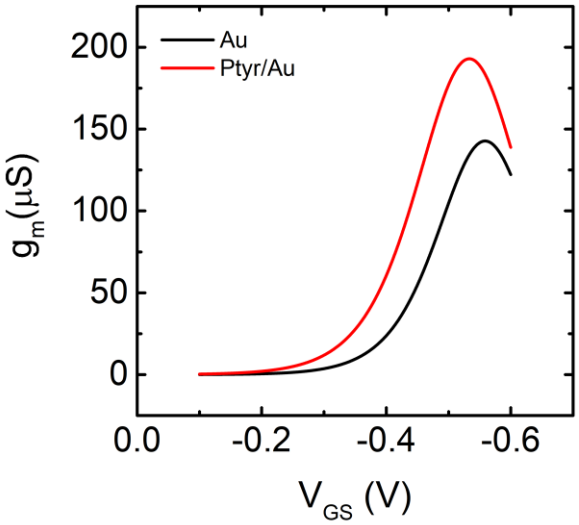
Acetaldehyde sensor

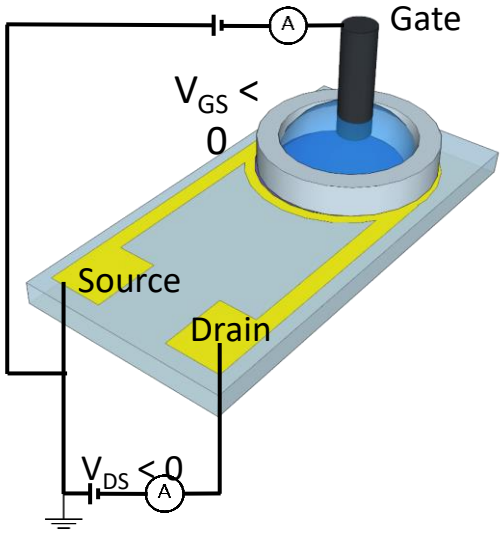
Acetaldehyde (HAc) sensing with DPP-DTT semiconductor

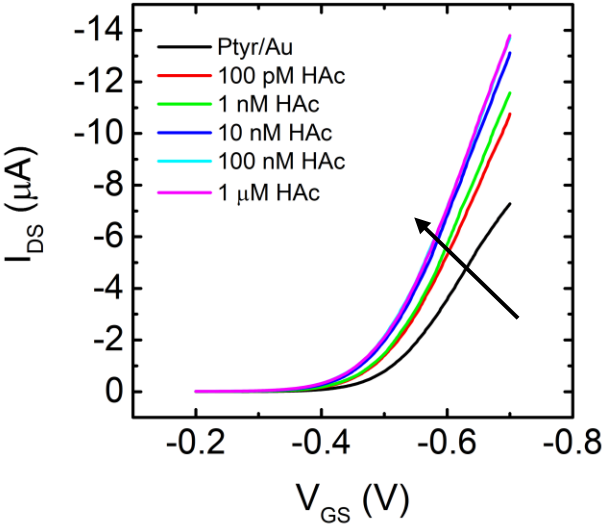


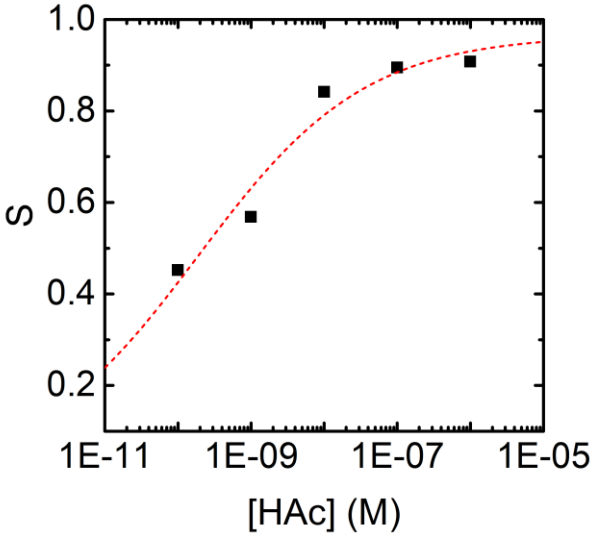
DPP-DTT





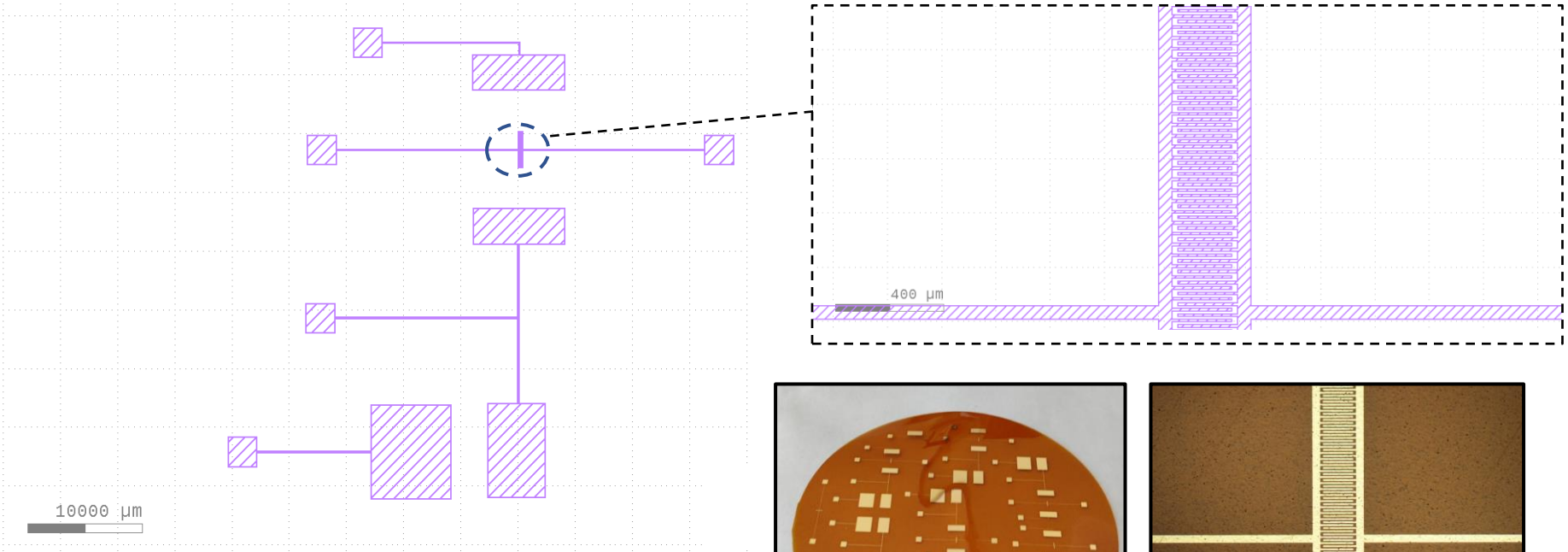




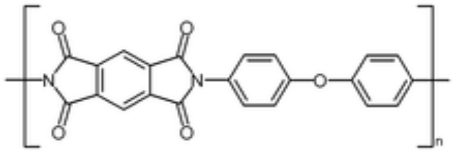


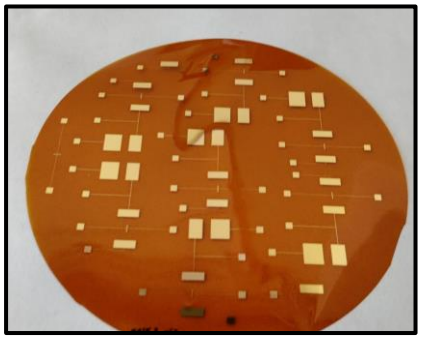
Conformable interdigitated electrodes

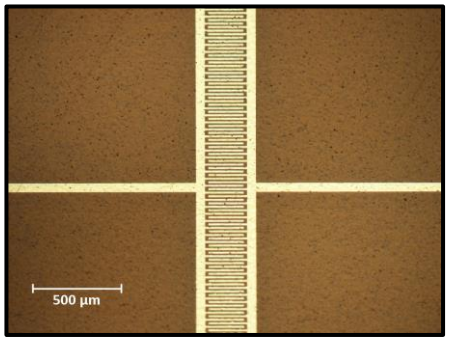
- New devices: gold on kapton (polyimide) conformable substrate (thickness = 75 µm)

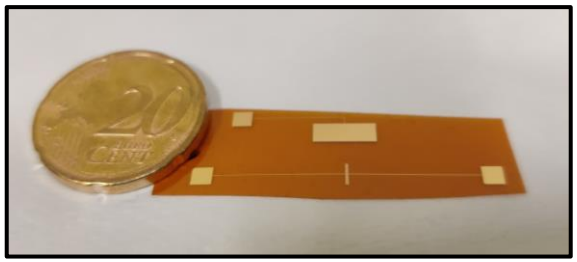


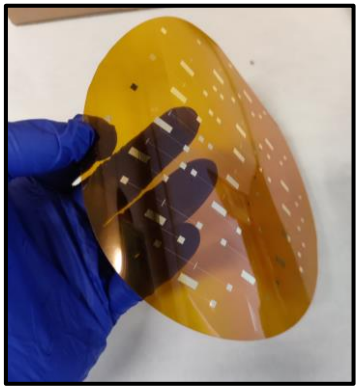
Kapton

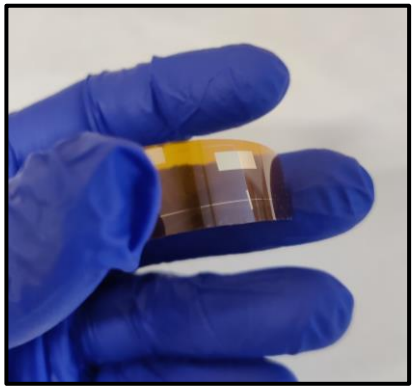






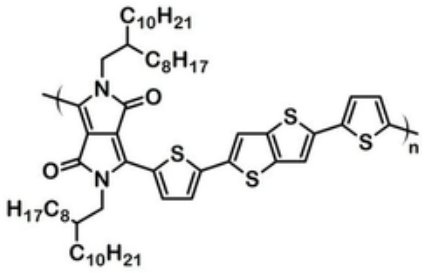




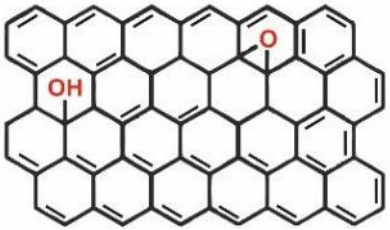


Au interdigitated electrodes on polyimide (Kapton)

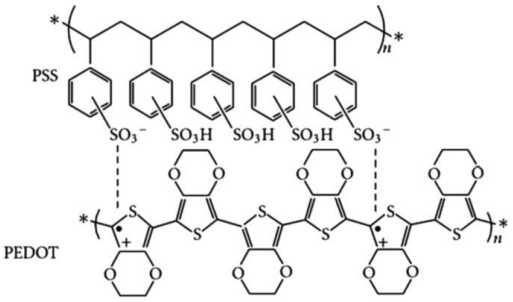
DPP-DTT

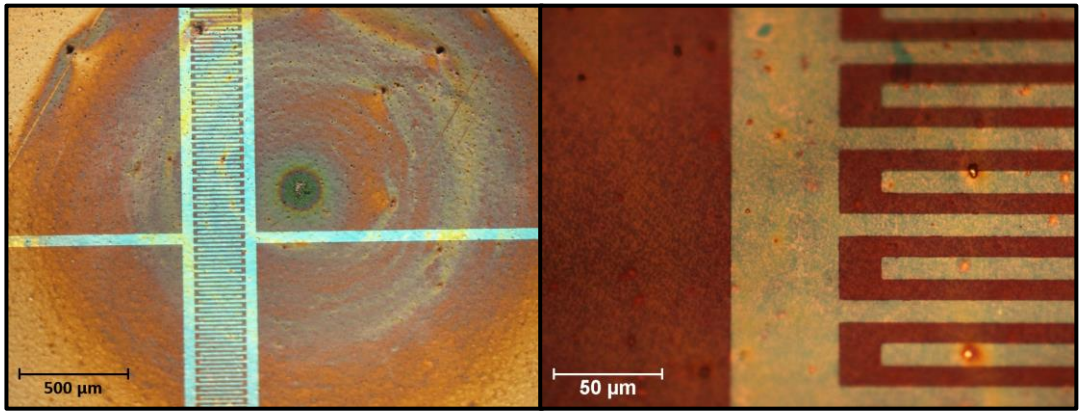


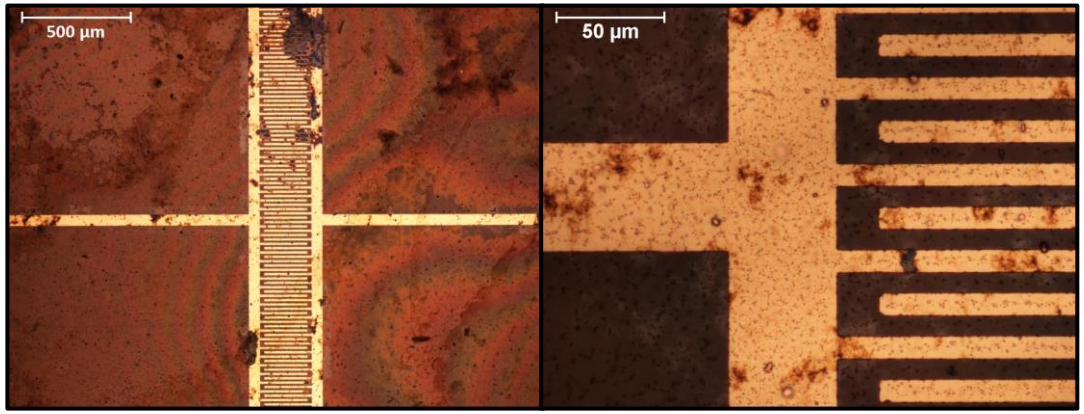
Reduced Graphene Oxide

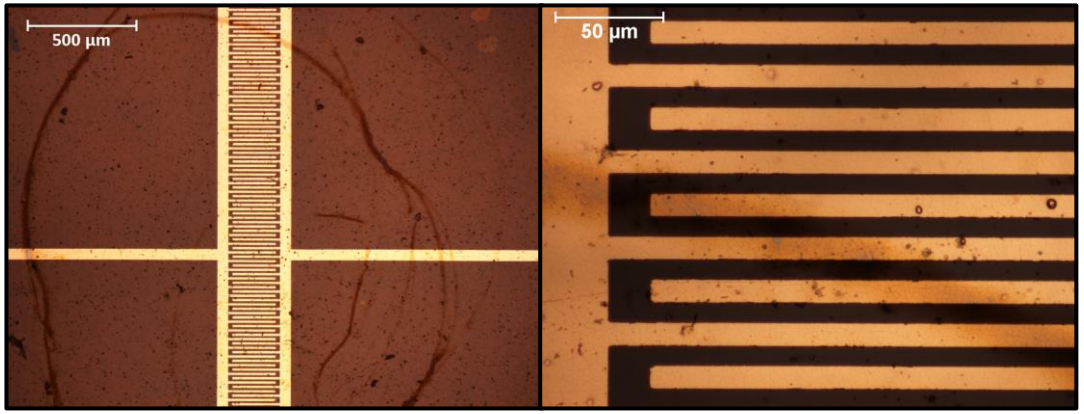


PEDOT:PSS









Conclusions

- Electrolyte-gated transistors based on **organic** materials and **graphene** are good candidates for food industry sensors to **reduce the food waste**
- We fabricated sensors prototypes based on organic electronics for food-freshness target analytes: **biogenic amines** and **acetaldehyde**
- We realized prototypes of **time-temperature integrators** based on reduced graphene oxide and PEDOT:PSS.
- We are working on making EGOT biosensors on **thin** and **flexible** materials, for packaging integration.

Acknowledgments

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ICHTHYS

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https://www.leo.unimore.it/

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TUS — Ireland

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Keywater Fisheries Sustainable Irish Perch — Ireland

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NutriFresco — Portugal

Packtin Economy meets circularity — Italy

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UNIMORE Università degli Studi di Modena e Reggio Emilia — Italy

Selonda Με την υπογραφή της θάλασσας — Greece

SuSea — The Netherlands

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Thank you for your attention

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Au interdigitated electrodes on polyimide (Kapton)

- Gold co-planar electrode (area = 24 mm^2)
- 1X PBS electrolyte