



HAL
open science

Dual gate organic thin film transistor for biosensing applications

Thibault Fresneau, Krunoslav Romanjek, Pascal Mailley

► **To cite this version:**

Thibault Fresneau, Krunoslav Romanjek, Pascal Mailley. Dual gate organic thin film transistor for biosensing applications. XVIIth GFB Conference -, Sep 2022, Saint Dié-des-Vosges, France. cea-04662895

HAL Id: cea-04662895

<https://cea.hal.science/cea-04662895v1>

Submitted on 26 Jul 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

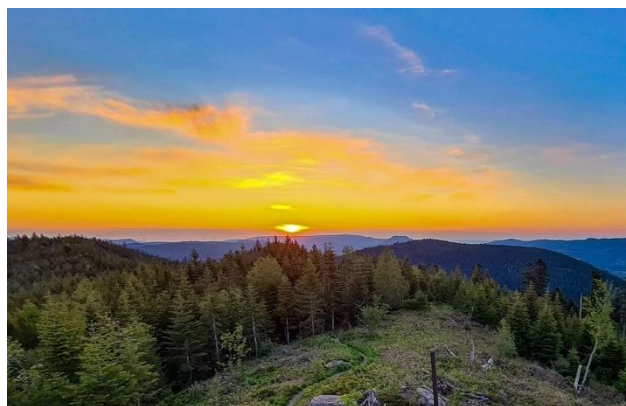
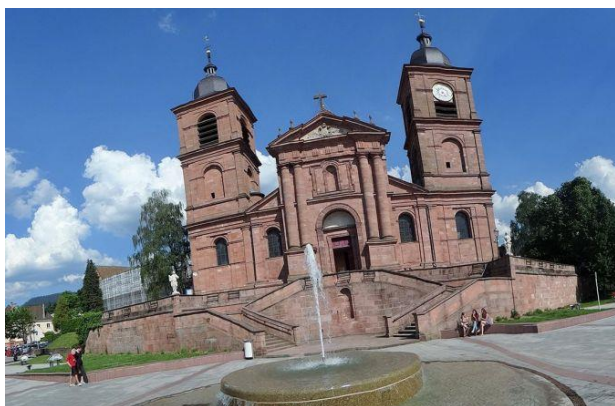
L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



XVIIth colloquium of the French Group of Bioelectrochemistry
XVII^{ème} colloque du Groupe Français de Bioélectrochimie
Saint-Dié-des-Vosges, September 26th- 29th 2022

Location : La Bolle (Village CAP France)

34 Chemin du Réservoir, 88100 Saint-Dié-des-Vosges, France : <https://la-bolle.fr/>



Conference Program:

Arrival and check in: Monday, September 26th 2022, afternoon; conferences start at 4:00 pm

Departure: Thursday, September 29th 2022, after lunch (2:00pm)

Themes :

- Modified Biosensors and Electrodes
- Biofilms and Biocorrosion
- Biofuel cells
- Development of biochips and integrated systems
- Proteins Electrochemistry and Biomimetism
- Electrochemistry of Cells and Tissues

Invited Speakers :

Cecilia Cristea (*Univ. Cluj-Napoca, Rumania*)

Frederic Gloaguen (*Univ. Bretagne Occidentale, France*)

Christel Laberty-Robert (*UPMC, Collège de France, France*)

Fred Lisdat (*TUAS Wildau, Germany*)

Vincent Noël (*Univ. Paris Cité, France*)

Sophie Sacquin-Mora (*Univ. Paris Cité, France*)

Sabine Szunerits (*Univ. Lille, France*)

Organizing Committee :

Mathieu Etienne (Univ. Lorraine), Grégoire Herzog (Univ. Lorraine), Benoit Piro (Univ. Paris Diderot), Stéphane Arbault (Univ. Bordeaux), Florence Lagarde (ISA-Lyon), Fabien Giroud (Univ. Grenoble Alpes)

Deadlines

Abstract submission: **May 25th, 2022**

Registration: **June 30th, 2022**





<https://www.bioelectrochimie.fr/>

XVIIth colloquium of the French Group of Bioelectrochemistry

XVII^{ème} colloque du Groupe Français de Bioélectrochimie

Saint-Dié-des-Vosges, September 26th- 29th 2022

Communication information:

Person: Mr

Family Name: Fresneau

First Name: Thibault

Laboratory: Organic Components Laboratory

University / Company: LITEN/CEA Grenoble - Université Grenoble Alpes

Address: 17 avenue des martyrs, 38000 Grenoble

e-mail: thibault.fresneau@gmail.com

Tel: 0632891838

Abstract title: Dual Gate Organic Thin Film Transistors for biosensing applications

Authors : Thibault FRESNEAU, Krunoslav ROMANJEK, Pascal MAILLEY

Type of communication:

- Oral - talk
Poster/Flash Com'
No choice

Interest to submit a manuscript to a Special Issue of *Bioelectrochemistry*:

Would like to be considered

Limit of submission: May 25th, 2022

Send your abstract and form to: gfbioelectrochimie@gmail.com

Please use the abstract guideline below:





Dual Gate Organic Thin Film Transistor for biosensing applications

T. Fresneau¹, K. Romanjek¹, P. Mailley¹

¹ *Univ. Grenoble-Alpes, CEA Liten, 38045 Grenoble, France*

thibault.fresneau@cea.fr

Organic electronics have brought numerous assets for the sensor industry. They have enabled fast and easy prototyping thanks to solution processable materials and large-area processing. In addition, biocompatibility and flexible substrates make them suited for biodetection and diagnosis applications. In particular, Organic Thin Film Transistors (OTFTs) have demonstrated their potential for biosensing, achieving very low detection limits and high selectivity. However, existing structures of OTFT-biosensors often limit the use of materials with poor-stability in air or water sensitivity because it exposes the Organic Semi-Conductor (OSC) to the analyte. In this work, we designed, manufactured and characterised a Double-Gate OTFT (DG-OTFT) architecture that protects the OSC from direct analyte interaction, and we investigate its potential for biosensing applications.

The device is made of a single-gate OTFT from [1] that we modified to add a second gate electrode on the other side of the OSC channel, as presented in **Figure (a)**. This architecture was inspired from [2] and [3] with two separate gates : one to tune the operation point of the device and the other to be linked to a sensitive area functionalised with bioreceptors. The defined process combines versatile methods and materials from the industry : the OSC and organic dielectric layers are spin-coated on the flexible substrate, gold electrodes and channel are patterned through photolithography, and top-gate electrodes are screen-printed with conductive polymer PEDOT:PSS. Two materials are used for the sensitive surface : PEDOT:PSS or Gold. The **Figure (c)** exhibits a DG-OTFT at the end of the process.

To characterise the potential of our DG-OTFT for biosensing, we conducted double-gate operation measurements : one gate voltage sets the operation point and the other mimics a biological charge recognition on the sensitive surface. This leads to a response-surface of the drain to source current versus both gate voltages that is presented in **Figure (d)**. **Figure (e) and (f)** are projections of the response-surface along bottom and top gate voltages, they were used to extract intrinsic parameters (threshold voltages, mobility of carriers). Those measurements exhibit the electrostatic interdependence of the threshold voltages for the double-channel architecture, and the results were used to identify the best operation point that ensures the highest transconductance (the drain current amplification gain).

Physical characterisation have been conducted to validate the geometrical parameters extracted from the electrical measures. Optical microscopy, mechanical profilometry and Scanning Electron Microscopy were used to measure the thicknesses of the organic layers and the length and width of the channel. Preliminary results of a Silane-Epoxy functionalisation process followed by oligonucleotide grafting (illustration in **Figure (g)**) have been analysed to qualify the robustness of the devices, showing no critical deterioration of the electrical performance (**Figure (h)**). These results are promising for further functionalisation with aptamer bioreceptors or thiolated oligonucleotides.

This work demonstrates the potential of the Double-Gate architecture of OTFTs for biosensing, now leading to extensive testing of the biofunctionalisation process and detection limit evaluation.

[1] M. Charbonneau et al., in 2018 48th European Solid-State Device Research Conference (ESSDERC), Sep. 2018, pp. 70–73. doi: 10.1109/ESSDERC.2018.8486895.

[2] S. Lai et al., *Org. Electron.*, vol. 46, pp. 60–67, Jul. 2017, doi: 10.1016/j.orgel.2017.03.038.

[3] Y. Zhang et al., *ACS Appl. Mater. Interfaces*, vol. 9, no. 44, pp. 38687–38694, Nov. 2017, doi: 10.1021/acsami.7b09384.



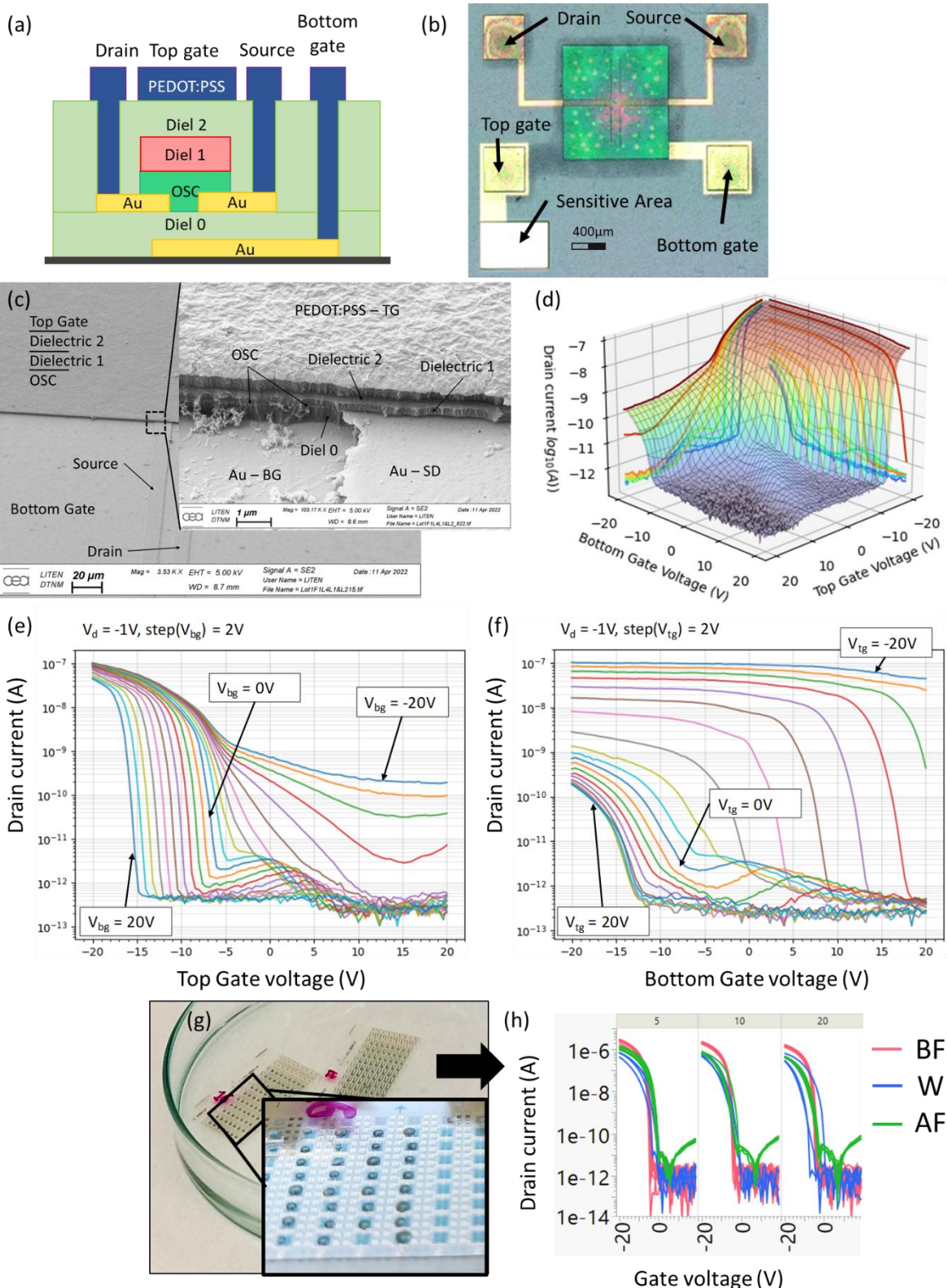


Figure 1 - (a) Cross-view schematic of the DG-OTFT (b) optical photograph of a DG-OTFT after processing (c) Scanning Electron Microscopy of the cross-section of DG-OTFT channel (d) Drain current surface-response for the double-gate operation of one DG-OTFT (e) projection of surface-response along Top Gate voltage (f) projection of surface-response along Bottom-Gate voltage (g) photograph of the functionalisation process buffer bath (enclosed) deposition of 500nL droplets of oligonucleotide charged buffer on Single Gate OTFT sample (h) transfer curves for Single Gate OTFT 'BF' before the functionalisation process 'W' witness samples without oligonucleotide deposition 'AF' after the functionalisation process