Master in Photonics – "PHOTONICS BCN"
Master ERASMUS Mundus "EuroPhotonics"

MASTER THESIS PROPOSAL

Laboratory: Department of Electronics and Biomedical Engineering
Institution: University de Barcelona (UB)
City, Country: Barcelona, Spain
Title of the master thesis: Fully inkjet printed photodetectors using graphene and perovskite inks for wearable applications.

Name of the master thesis supervisor and co-supervisor:
Blas Garrido and Junaid Khan
Email address: blas.garrido@ub.edu, junaidkhan@ub.edu
Phone number: +34 612252659
Mail address: Department of Electronics and Biomedical Engineering, Facultad de Física de la Universitat de Barcelona.

Scholarship: Eligible for a scholarship

Keywords: Perovskites, graphene, inkjet printing, photodetectors, wearable applications
Objective:
To fabricate a fully inkjet printed photodetectors using perovskites and graphene inks and demonstrate its application for wearable devices.

1. **Summary of the subject (maximum 1 page):**

Inkjet printing technology is set to outpace traditional lithography for creating flexible, stretchable, and sustainable electronic devices due to its precision, cost-effectiveness, scalability, and eco-friendly benefits [1]. Key to its success are conductive inks—comprising nano- or microscale materials like silver, graphene, or carbon nanotubes in optimized solvents—that enable precise control over conductivity, print quality, and adhesion, essential for advanced devices as shown in Fig 1. Perovskites further enhance optoelectronics with their superior light absorption, tunable bandgap, and defect resilience, making them ideal for solar cells, LEDs, and photodetectors. Their compatibility with inkjet printing supports the scalable development of lightweight, high-performance optoelectronic devices, advancing new possibilities in photonics and electronics [2]. When combined with materials like graphene, which offers exceptional electronic mobility, perovskites enable advanced, fully printed photodetectors. This synergy between perovskites' optical properties and graphene's electronic characteristics opens pathways for novel, layered device architectures that drive innovations in energy, displays, and environmental sensing [3]. The solution processability of graphene and perovskites materials make it possible to prepare inks suitable for inkjet printing. Sequential printing of graphene and perovskites ink will create interfaces that will cause photoluminance quenching converting light signals into electrical signals as illustrated in Fig 2. The photocurrent generated will be proportional to the intensity of illumination due to the transfer of holes

at the interface between perovskite and graphene which will be highly dependent on the printing layer thickness and interfacial interactions.

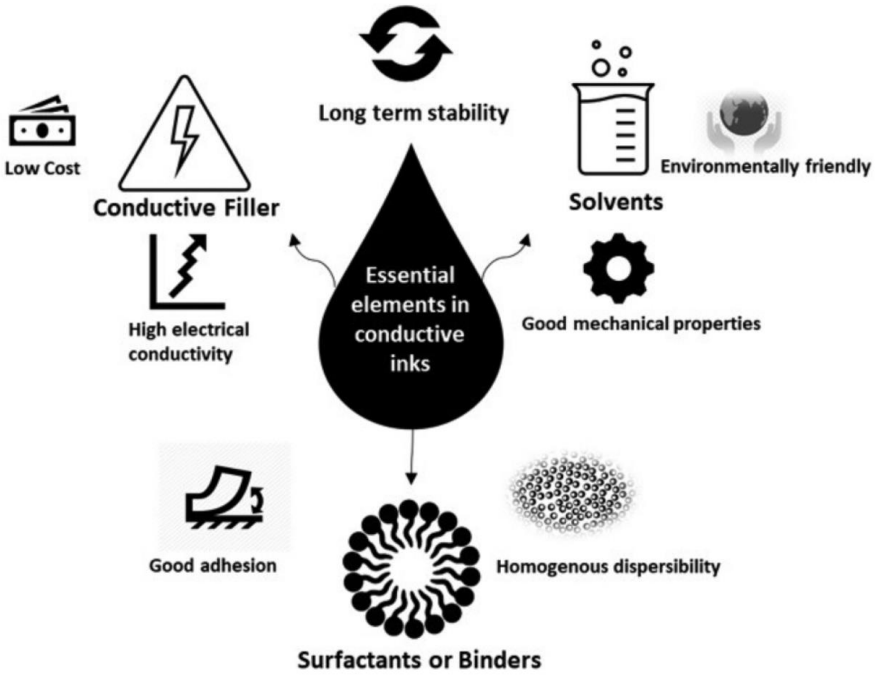

Fig 1. Summary of the most essential elements and properties considered for conductive inks preparations [4]

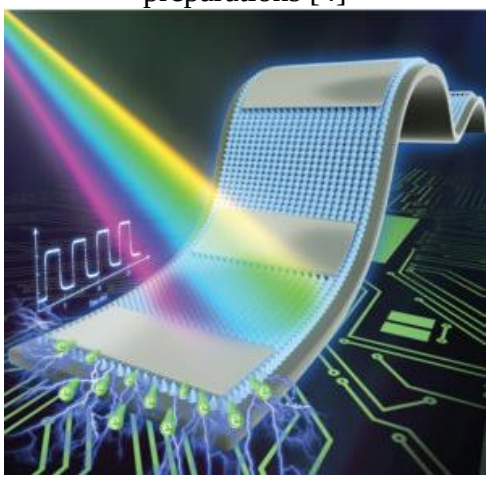

Fig 2. Illustration of conversion of light energy into electrical signals [5]

The master student will be integrated in the ongoing European Union project “PIXIE SENS” to develop fully inkjet printed photodetectors for wearable sensing applications. In principle the student will be involved in ink formulations, inkjet printing and studying the effect of varying printing parameters on the performance of fully inkjet printed photodetector devices on various substrates such as polyester, glass and polyimide.

2. **Workplan and timeline:**

Sr. No	Timeline (months)	1st	2nd	3rd	4th	5th	6th
1	**Literature Review**						
2	**Starting hypothesis and objectives**						
3	**Formulation of conductive and active inks**						
4	**Inkjet printing process optimization**						
5	**Device fabrication : photo detector and a wearable optical sensor**						
6	**Characterization, testing and interpretation**						
7	**Final report, thesis writing and presentation**						

3. **Key learning outcomes**

- Mastering of inkjet printing techniques and other fabrication techniques like spin coating and evaporation
- Integration of physics, materials science, optoelectronics and photonics
- Analytical and characterization expertise including material properties, lasers, detectors and optoelectronic measurements
- Project management and research skills
- Innovation and problem solving in cutting-edge technologies
- Working in an international group with possibilities of continuing research activities

4. **References:**

[1] J. Khan and M. Mariatti, "Effect of natural surfactant on the performance of reduced graphene oxide conductive ink," *J. Clean. Prod.*, vol. 376, p. 134254, Nov. 2022, doi: 10.1016/j.jclepro.2022.134254.

[2] G. Vescio *et al.*, "Fully Inkjet-Printed Green-Emitting PEDOT:PSS/NiO/Colloidal CsPbBr 3 /SnO 2 Perovskite Light-Emitting Diode on Rigid and Flexible Substrates," *Adv. Eng. Mater.*, vol. 25, no. 21, p. 2300927, Nov. 2023, doi: 10.1002/adem.202300927.

[3] S. Akhavan *et al.*, "Graphene-Perovskite Fibre Photodetectors," *Adv. Mater.*, vol. 36, no. 35, Aug. 2024, doi: 10.1002/adma.202400703.

[4] Y. Z. N. Htwe, M. Mariatti, and J. Khan, "Review on solvent- and surfactant-assisted water-based conductive inks for printed flexible electronics applications," vol. 35, no. 18, Jun. 2024, doi: 10.1007/S10854-024-12927-4.

[5] X. Jin *et al.*, "High-Performance Free-Standing Flexible Photodetectors Based on Sulfur-Hyperdoped Ultrathin Silicon," *ACS Appl. Mater. Interfaces*, vol. 11, no. 45, pp. 42385–42391, Nov. 2019, doi: 10.1021/acsami.9b16667.


UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

UAB
Universitat Autònoma
de Barcelona

UNIVERSITAT DE
BARCELONA

ICFO

euroPHOTONICS
ERASMUS MUNDUS
Erasmus+