



Master in Photonics – “PHOTONICS BCN” Master ERASMUS Mundus “EuroPhotonics”

MASTER THESIS PROPOSAL

Starting full time from April 2024

Presentation at the end of July or beginning of September 2024

Laboratory: Optoelectronics and Inkjet Printing

Institution: University of Barcelona

City, Country: Barcelona, Spain

Title of the master thesis:

Inkjet printed matrices of LEDs and image sensors with perovskite materials

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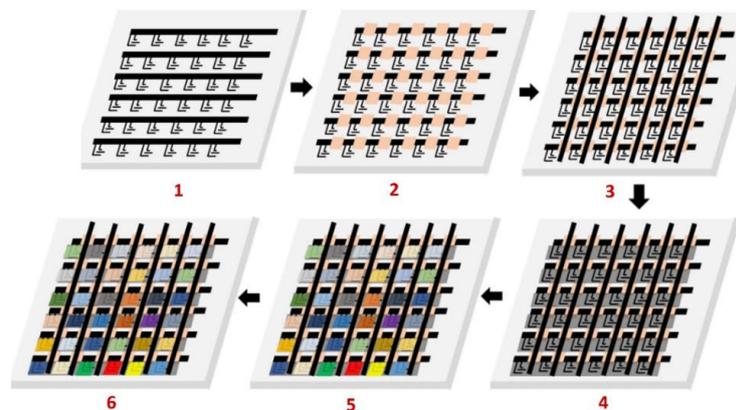
Summary of the subject (maximum 1 page):

Optoelectronic devices (LEDs, photodetectors, lasers, solar cells, displays, sensors) have become as indispensable as electronic circuits or chips themselves. According to the economic data analysis website Precedence Research (<https://www.precedenceresearch.com/>), the global optoelectronics market was valued at \$6.54 billion in 2022, reached \$7.36 billion in 2023, and is estimated to reach \$21.2 billion by 2032, with a remarkable compound annual growth rate (CAGR) of 12.48% from 2023 to 2032. There are many technological platforms and materials used in the manufacturing of optoelectronic devices and photonic integrated devices (PICs), including compound semiconductors III-V (such as GaAs, InP, GaN) and their ternary and quaternary alloys, metal oxides (ZnO, SnO₂, NiO), II-VI or chalcogenides (ZnS, CdS, ZnSe), and various organic semiconductors. All these devices and technologies require complex deposition equipment that operates at high temperatures, uses toxic gases and chemicals, and relies on large lithography technology to define the circuits. Therefore, PICs are manufactured in semiconductor foundries, the majority of which are located outside Europe, particularly in the Far East.

However, it would be better to use alternative or complementary semiconductor materials and more accessible and cost-effective technologies. The perovskite halides are processed in solution and do not require intensive resource usage. They are materials processed in solutions at room temperature, do not require significant energy resources for their production, do not need hazardous gases or chemicals, and are abundant materials. Therefore, their production is not dependent on the complex supply chains that characterize mainstream microelectronics and photonics technology. For all these reasons, they contribute to sustainability and have a much smaller environmental impact and carbon footprint than traditional semiconductors. We propose the

fabrication of optoelectronic and photonic devices with these materials and inkjet printing wasteless technology that eliminates the need for lithography.

This TFM aims to valorise the inkjet printing technology of perovskite halides developed in previous projects of the group for the fabrication of photonic integrated circuits (PICs). We will fabricate one precompetitive demonstrator: i) A photodiode array as an image sensor in the visible and/or infrared spectrum. Device encapsulation and packaging with polymers will be done for extended lifespan. A technical and commercial feasibility analysis of the technology and devices will be conducted. Therefore, we aim to optimize the devices for higher efficiency and durability and achieve functional arrays successively of 8x8 and 16x16 pixels. For this purpose, we will use lead-free 3D FASnI₃ perovskites, and hybrid 2D-3D A₂SnX₄ perovskites (A= PEA, TEA; X=I, Br), as well as the double perovskite Cs₂(Ag_{1-x}Na_x)InCl₆:Bi.



Objectives:

- 1) Inkjet printing of layers of perovskites without pinholes and good morphology
- 2) Fabricating single photodiodes with perovskite and transport layers
- 3) Measuring optical and electrical properties
- 4) Design, manufacture and test of the matrices working as image sensors