Lab project M2 PPN

Monday & Tuesday from Nov. 2026 to March 2027

Title of the project: Nanofabrication of light-emitting artificial neurons

Supervisor(s): Maciej Ćwierzona

Laboratory / Department / Team : ICB/Photonics/PRISM

Collaborations:

Summary:

Artificial neurons based on ***nanoscale resistive switching devices*** offer a promising route toward neuromorphic systems in which electrical signals can be coupled directly to optical emission. In particular, filamentary switching devices can exhibit dynamic fluctuations in conductance and light emission associated with the formation and evolution of nanoscale conductive pathways. Understanding and controlling these processes requires devices with well-defined geometries and material interfaces.

The ***main objective*** of this lab project is to develop, optimize, and ***nanofabricate light-emitting artificial neurons*** based on resistive-switching devices. The student will investigate different combinations of switching materials, dielectric/oxide layers, and electrodes. A ***secondary objective*** will be to determine whether light-emission phenomena observed in specific material systems (Au/Ag) can be reproduced using more widely studied resistive-switching materials and mechanisms, thereby assessing the generality of light-emitting behavior in memristive devices beyond particular metallic systems.

The ***core activity*** of this project will include the ***nanofabrication*** of device structures with controlled dimensions using a ***maskless photolithography*** process, as well as their ***structural, electrical, and optical characterization***. Depending on the project's progress, particular attention might be given to the electrical dynamics and electroluminescence of the new memristors.

This work will significantly contribute to a further objective: investigating the scalability of light-emitting memristive systems. Individual devices may be interconnected to form simple multi-device architectures, allowing the investigation of whether the electrical and optical dynamics observed at the single-device level can be reproduced and controlled in networks of artificial neurons. Such structures could provide a first step toward more complex neuromorphic systems in which information is processed and communicated through both electrical and optical signals.

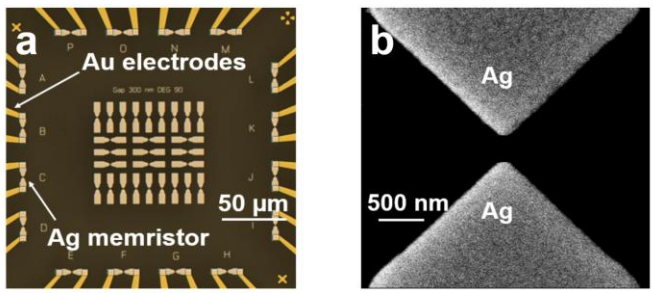


Figure 1. (a) Example of a nanofabricated memristive sample. (b) SEM image of a single memristive junction.

Type of project (theory / experiment): experiment

Required skills: basic electronics, optics, programming (Python, LabVIEW), conversational English

Future reading: Citri, R, et al., Neuropsychopharmacol 33, 18–41 (2008) ; K. Malchow, et al., ACS Nano, 18, 35, 24004-24011 (2024); D. Singh, et al., Advanced Electronic Materials, 12(15) (2026); W. Sun, et al., Nat Commun, 10, 3453 (2019)