Assembling a biohybrid energy harvester based on living plants and measuring electrophysiological signals in plants

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In-person event

Abstract:

During the workshop, students will build a biohybrid wind energy harvester based on a living plant and flexible soft electrodes generating electricity from leaves' motion created by wind. Students will be assessing different materials and electrodes shapes and as a result learn how plants and their natural materials can integrate into a biohybrid device for producing electricity. The students will also learn about the triboelectric effect, how different materials influence it and how it occurs in plants. The final challenge is to create a simple circuit to harvest the energy and power as much LEDs as possible. Moreover, students will learn how to record the tiny electrophysiological signals that plant cells produce to communicate using the carnivorous Venus flytraps.

Program

A) Introduction: A presentation on plant hybrid devices for energy harvesting, the triboelectric effect and plant intrinsic electrophysiological signals and how to measure them will be given providing background for the practical part (25 min)

B) Practical part 1: Construction of soft artificial leaves for plant hybrid energy converters - Selection of best materials for highest power outputs based on the triboelectric effect on leaves.

To Do: Transparent ITO-coated PET electrodes will be merged with different materials (PTFE, silicone rubber, polyamide, etc.) to obtain artificial leaves for translating mechanical energy on the leaves in surface charges by the triboelectric effect. The materials will be cut in the desired shapes for attachment and installation on a real plant (e.g., Rhododendron). It will be investigated which materials lead to highest surface charging by measuring the voltage between the plant tissue and the artificial leaves when stimulated by a mechanical force (applied by hand or wind/fan) using an oscilloscope. Best performing artificial leaves will be used for further experiments.

Keywords: transparent electrodes, soft materials, triboelectric effect, biohybrid, energy conversion, adaptation artificial-biological

C) Practical part 2: Different circuits for harvesting the electrical signals generated by the plant

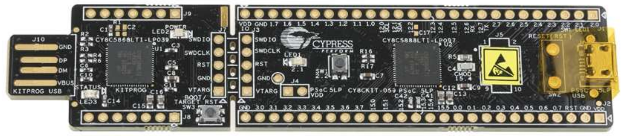
To Do: Different circuits will be tested for harvesting the electrical signals obtained by the plant-hybrid generators. This includes for example investigating of how the connection to the plant tissue, rectifiers (diode bridges), single or double electrode modes, etc. affect the signal amplitudes.

Furthermore, it will be tested how the current spikes produced by the leaf triboelectrification can directly power LEDs using a single leaf.

Keywords: Energy harvesting, electrical circuits, plant-hybrid generators

D) Practical part 3: Building a circuit to charge a capacitor and program a prototyping platform to monitor the capacitor charging as function of mechanical stimulation of the plant-hybrid generator.

To Do: The plant-hybrid generators will be connected to a rectifying circuit to charge a capacitor and the voltage across the capacitor will be monitored using a microcontroller prototyping platform (e.g., CY8CKIT-059 by Cypress Semiconductor). Charging behavior during mechanical stimulation and phases without stimuli will be recorded. The charging curves of different capacitors will be recorded.



Keywords: Electrical circuits, setting-up a prototyping platform

E) Practical part 4: Measuring electrophysiological signals in the Venus flytrap.

To Do: Plants also create their own electrical electrophysiological signals that cells use to communicate. These signals can be recorded by another electrode configuration. Therefore, the mechanosensors of Venus flytraps will be stimulated and electrical signals recorded between a reference electrode in the ground and a surface potential electrode on the Venus flytrap leaf surface. The signal corresponds to ion movements through the cell membrane of cells of the trigger hairs that the Venus flytrap uses to catch their preys. The prototyping platform (e.g., CY8CKIT-059 by Cypress Semiconductor) will be used and the program modified for measuring the electrical signals.

Keywords: Measuring plant electrophysiology, setting-up a prototyping platform, plant-electronics interfaces