Kinetic energy harvesting system based on selective ion sweeping under flow shear on capacitive electrode

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When flowing electrolyte over a capacitive electrode, ions adsorbed on the electrode surface are swept away due to the interfacial shear stress. If this ion sweeping occurs at only one electrode of a circuit, it induces potential bias and can thus generate electric current [1]. This phenomenon enables us to harvest various types of kinetic energy on different scales (e.g. microbiological dynamics, human motions, ocean tide) and convert to useful electric energy sources. For this, a key is 1) to understand how the hydrodynamic parameters quantitatively regulate the ion sweeping effect and electrochemical responses, and 2) to design novel hydrodynamic-electrochemical hybrid device structure that is efficient for the energy transformation.

In this work, we create a selective ion sweeping device by incorporating ITO electrodes into a microfluidic channel with an architecture exposing only one of the two electrodes to strong interfacial shear stresses. We characterize electrochemical responses of this device as a function of the flow shear applied at the electrode surface. This requires flow shear measurements with high spatial and temporal resolution near the channel walls. We have developed such a technique using the shear-induced orientation behavior and the polarized photoluminescence property of LaPO4:Eu nanorods [2]. We can thus characterize the shear flow in our energy harvesting device by adding LaPO4:Eu nanorods to the electrolyte and collecting their polarized emission under flow. This allows us to study the fundamental relationship between shear flow and ion sweeping and aids in the optimization of the device.

References

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