AC-driven light emission from in-situ grown organic nanofibers

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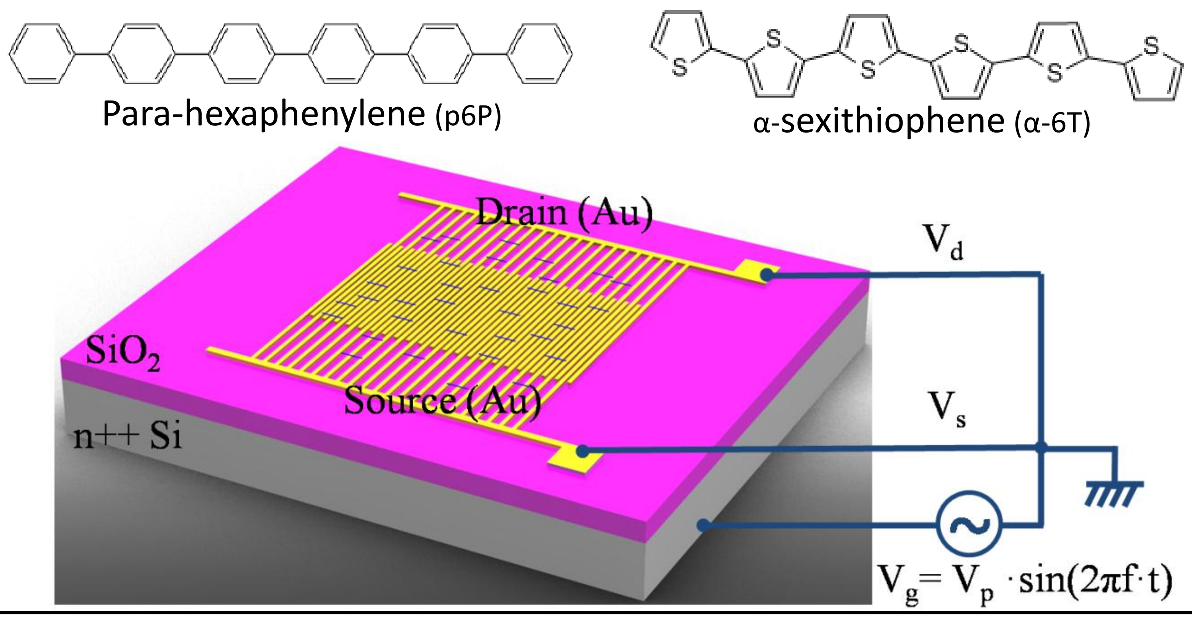
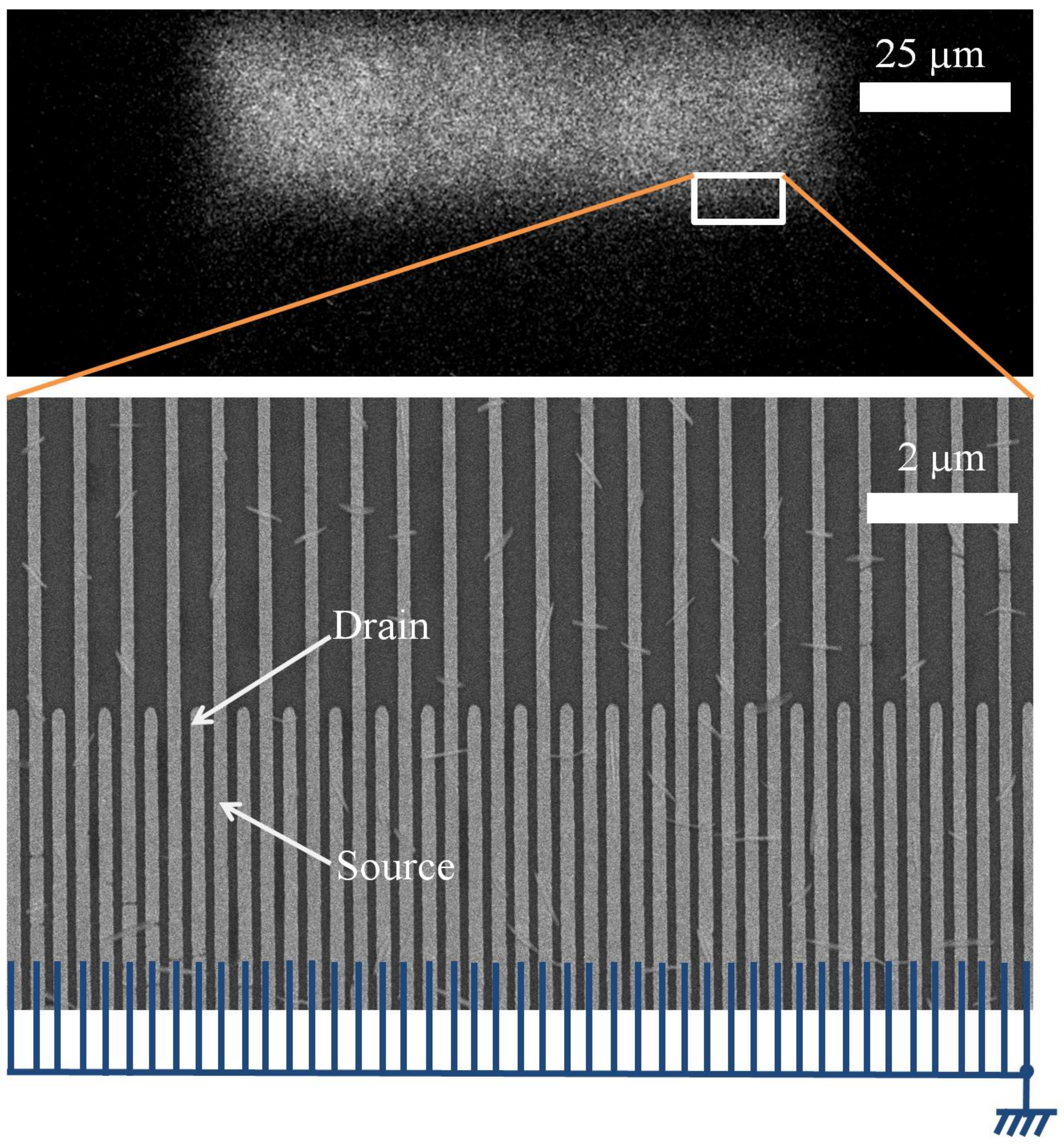
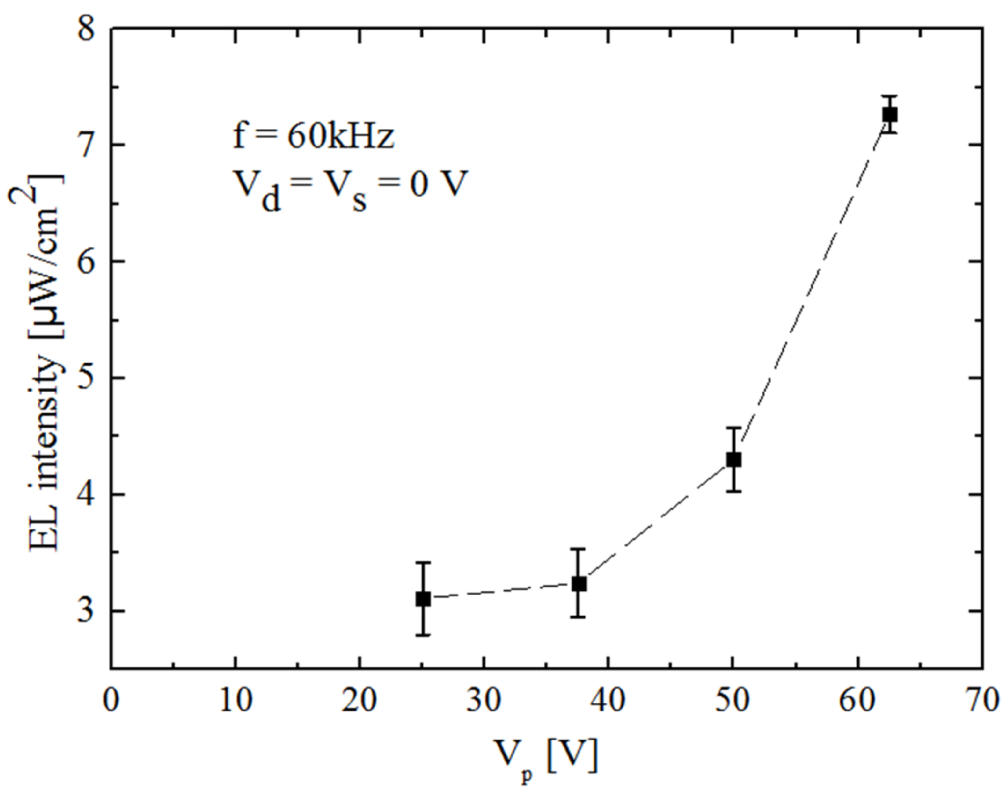
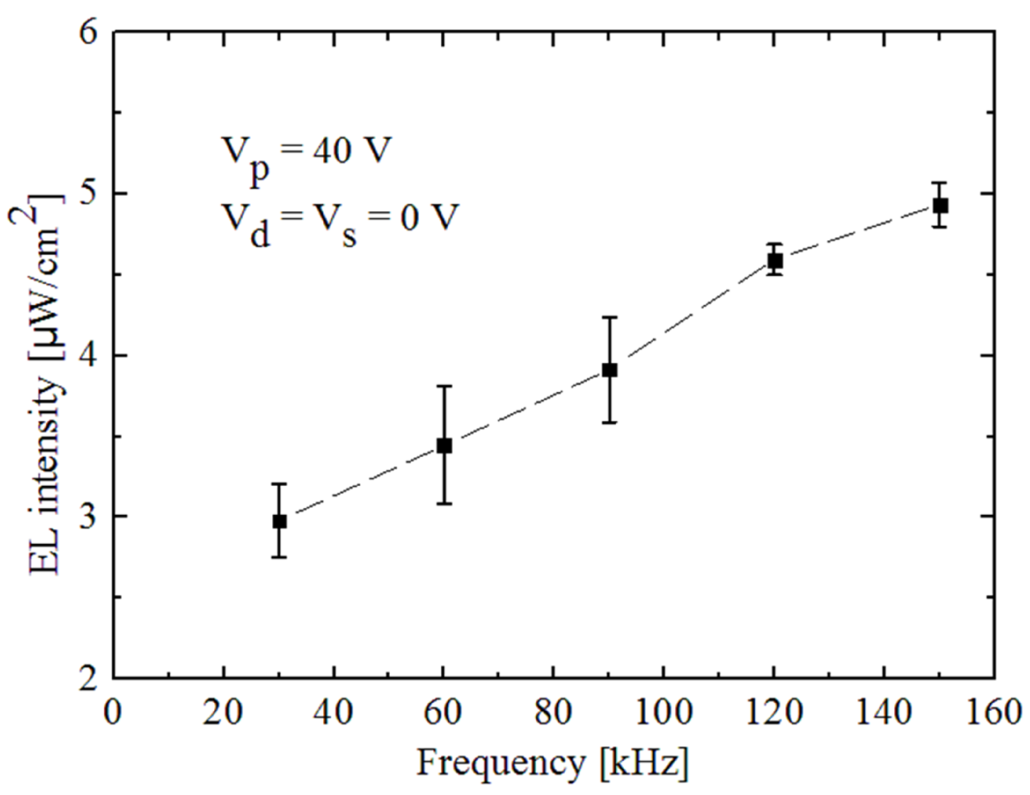
In-situ grown organic nanofibers have been prepared on metal electrodes patterned by electron beam lithography (EBL). A systematic investigation shows that the light emission from these nanofibers driven by an AC gate voltage depends non-linearly on the amplitude of the AC gate voltage and linearly on the frequency of the gate voltage, which indicates that a model involving space charge field (SCF) assisted electron tunneling can be applied. The photoluminescence spectra of para-hexaphenylene (p6P) and α-sexithiophene (6T) nanofibers illustrate that the emission color of the in-situ grown nanofibers can be tuned by depositing two types of discontinuous organic layers on the same platform.



AC-driven luminescence

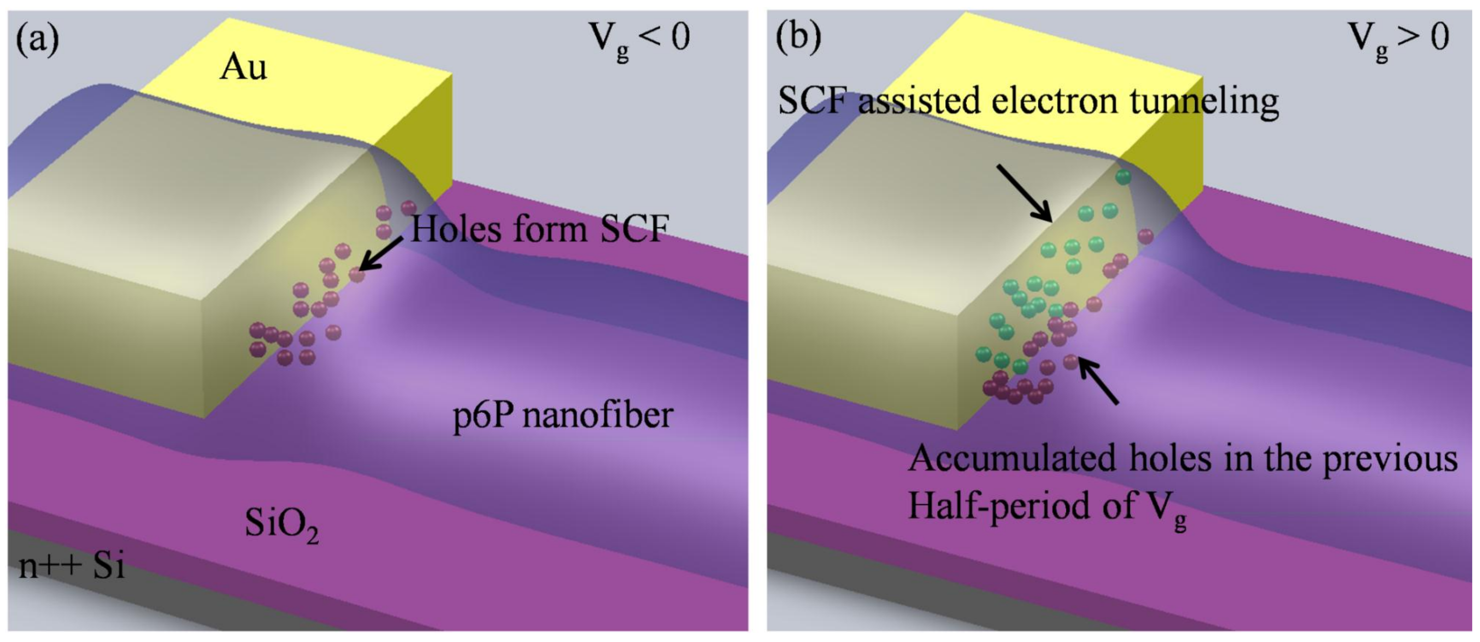






The light emission intensity from a nanofiber based device depends non-linearly on the AC voltage amplitude and linearly on the AC gate voltage frequency, which is similar to the dependence obtained from a thin film based device [1]. This indicates that a model based on SCF assisted electron tunneling can be applied [2].

The light emission obtained by grounding both metal electrodes and applying an AC voltage to the gate indicates that there is no charge carrier transporting between two metal electrodes; rather, the light emission is due to the subsequent injection of holes and electrons from the same metal electrode requiring a sufficiently high field strength to be provided at the electrode edge by the gate voltage.



Model:

(a) During the negative half-period of the gate voltage, holes inject from the Au electrode due to the electric field and form a positive space charge field;

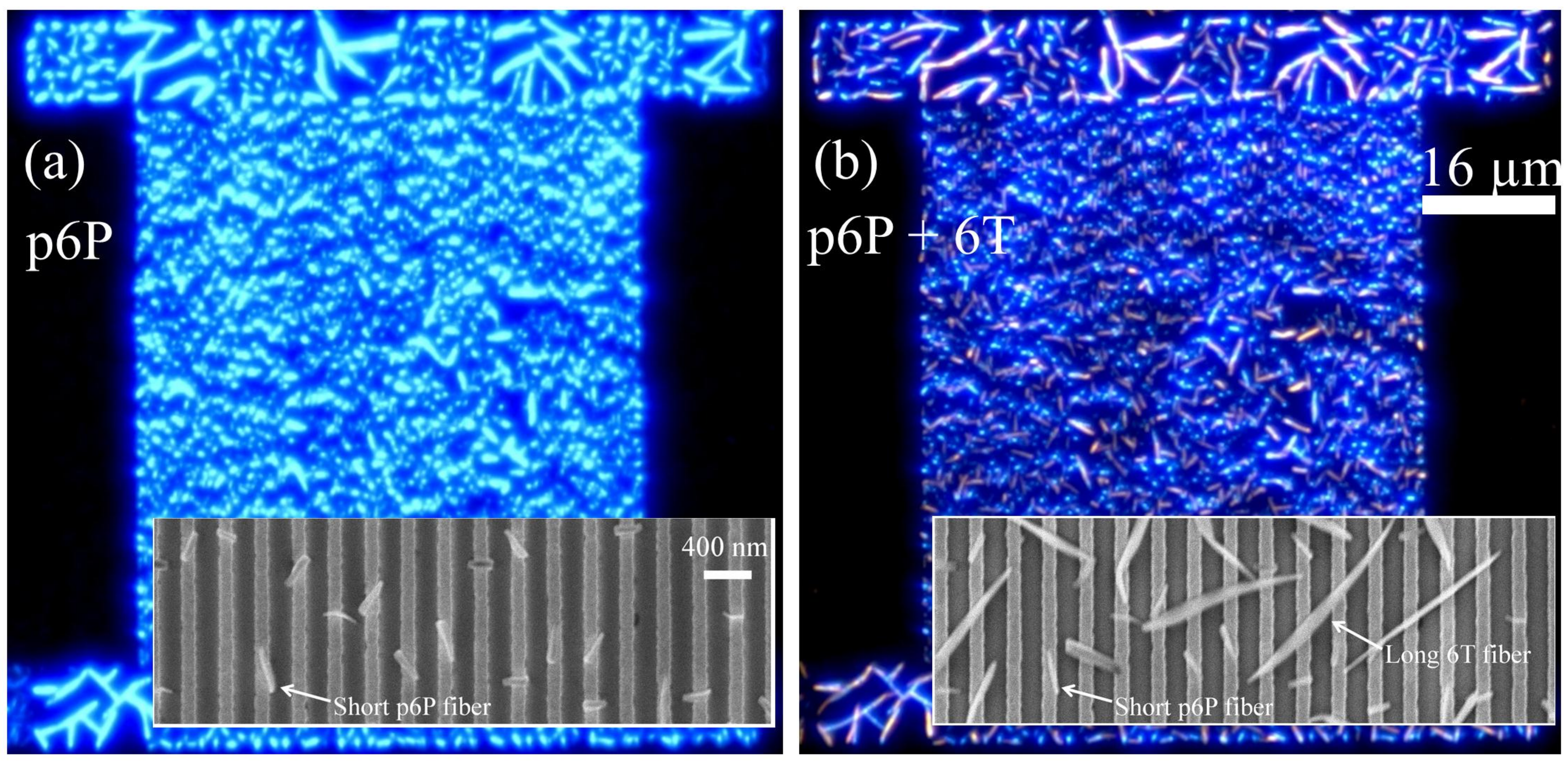
(b) During the positive half-period of the gate voltage, electrons tunnel out assisted by the positive space charge field, recombining with the holes injected in the previous step.

[1]: X. Liu et al. "AC-biased organic light-emitting field-effect transistors from naphthyl end-capped oligothiophenes" Org. Electron. Vol 11, p. 1096-1102 (2010)

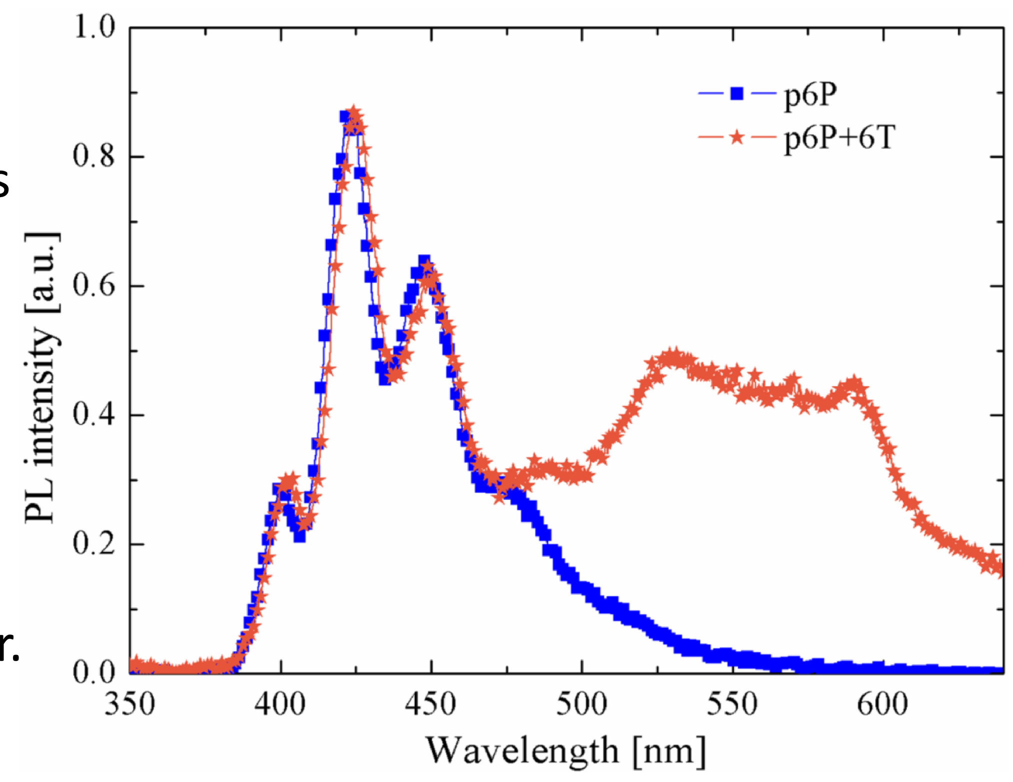
[2]: X. Liu et al. "Charge-carrier injection assisted by space-charge field in AC-driven organic light –emitting transistors" Org. Electron. Vol 12, p. 1724-1730 (2011)

Bi-layer nanofiber device

The fluorescence microscope images show a light-emitting device consisting of 3.5 nm p6P in-situ grown nanofibers (a), and the same device after being deposited a second layer with 7 nm 6T nanofibers (b). The inset SEM images illustrate that the 6T nanofibers can be well distinguished from the previously depostied p6P nanofibers.



The photoluminescence spectra suggest a reliable method to mix clean colors simply by sequentially growing nanofibers of two different molecules on the same device without changing the emission color of the first discontinuous organic layer.



Summary

In-situ grown p6P/6T nanofibers on nanoscale electrodes have been used to investigate AC-driven light emission. The emission color of the nanofibers can be tuned by depositing two types of discontinuous organic layers on the same platform.

Future work

Optimize the nanofiber in-situ growth on nanoscale electrodes in order to achieve a higher growth density. Investigate the influence of the thickness of the two materials on the resulting spectrum.