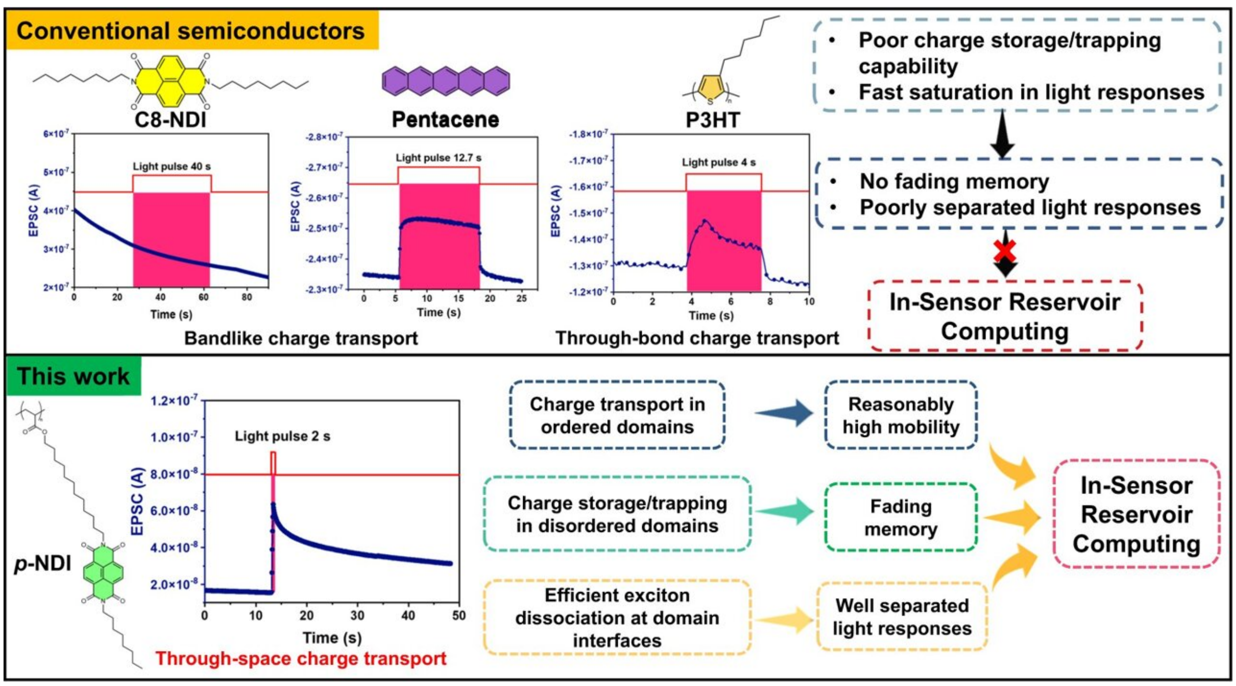
Wearable in-sensor reservoir computing for multitask learning via material-algorithm co-design strategy

February 24 2023, by Liu Jia



Comparison of the photocurrent responses of conventional semiconductors and p-NDI, and the detailed semiconductor design principle for in-sensor RC systems. The photocurrent responses of C8-NDI, pentacene, and P3HT, which are incapable for in-sensor reservoir computing. The photocurrent response of p-NDI shows a fading memory and is suitable for in-sensor reservoir computing. Credit: *Nature Communications* (2023). DOI: 10.1038/s41467-023-36205-9

The human retina not only senses light signals, but also processes them simultaneously by capturing their rich dynamics, thus accelerating the task-dependent learning in the down-stream visual cortex. This synergy of both the retina and the visual cortex has inspired in-sensor multi-task learning.

However, traditional silicon-vision chips suffer from the large time/energy overheads which are caused by the massive and frequent data shuttling and sequential analog-digital conversions among their separated sensing, processing and storage units. In addition, the slowdown of Moore's law further exacerbates the limitation. Therefore, devising a paired material-algorithm combining the artificial retina and reservoir computing (RC) is of significance for the sensing-computing systems with ultra-low energy overheads and ultra-fast computing speed.

In a study published in *Nature Communications*, the research group led by Prof. Huang Weiguo from Fujian Institute of Research on the Structure of Matter of the Chinese Academy of Sciences, achieved wearable in-sensor reservoir computing for multitask learning via a material-algorithm co-design strategy.

The researchers designed and synthesized a material-algorithm co-design, a light-responsive semiconducting polymer (p-NDI) with efficient exciton dissociations and through-space charge-transport characteristics to construct an in-sensor RC for multi-tasked pattern classification.

They found that the p-NDI-based flexible phototransistors exhibit well-separated light responses, nonlinear fading memory, and echo state property, enabling a wearable transistor-based dynamic in-sensor RC system.

This all-organic-materials-based RC system recognized handwritten letters and digits, and classified various costumes with accuracies of 98.04%, 88.18% and 91.76%, respectively. In addition to 2D images, the RC efficiently classified three types of spatiotemporal dynamic gestures (left-hand waving, right-hand waving and hand clapping gestures) at an accuracy of 98.62%.

This study not only overcomes the bottleneck associated with conventional sensing-computing systems of large time and energy overheads, but also provides a new material-algorithm co-design strategy for wearable, affordable, and highly efficient photonic neuromorphic systems.

More information: Xiaosong Wu et al, Wearable in-sensor reservoir computing using optoelectronic polymers with through-space charge-transport characteristics for multi-task learning, *Nature Communications* (2023). DOI: 10.1038/s41467-023-36205-9

Provided by Chinese Academy of Sciences