Supporting Information

Multiple Narrowband Bidirectional Self-Powered Organic Photodetector with Fast Response

Yuxin Xia[*1], Dimitra G. Georgiadou[*1,2]

[1]Electronics and Computer Science, University of Southampton, Highfield Campus, Southampton SO17 1BJ, United Kingdom.

[2]Optoelectronics Research Centre, University of Southampton, Southampton, United Kingdom

Supplementary Notes

Supplementary Note 1: Rationale for selecting the metal electrodes

Looking at the optical constants of all materials involved (Figure S1), we notice that the extinction coefficient, k, value of Silver (Ag) shows a valley around 320 nm along with sharp drop of the refractive index, n, value. This implies that both the reflection and absorption of light with wavelength around 320 nm could be low, if Ag is interfacing with a layer with suitable n values, e.g., $1<n<2$. Indeed this is the range of n values for many organic semiconductors, rendering the Ag selection as top electrode a safe choice for maximizing light transmission.

If we now consider the metal selection of the other electrode for the case when light is incident from the bottom (glass side), and we also take into account the requirement for work function matching of the metal to the organic materials' energy levels to achieve high photodiode performance, Au would be our first choice and Al is excluded because of its well-known high reflection within a wide wavelength range.

Au was selected as bottom electrode due to its more suitable optical properties. Through simulation, we validated this concept in a relevant device configuration, where an optimum Au thickness of 30 nm was calculated to result in a relatively large transmission window in the visible range, when the photoactive organic layer was also incorporated in the structure. All layers' (metal electrodes and organic layers) thicknesses optimization was performed via Transfer Matrix Method (TMM) run through a Python script to minimize the number of experiments that would be otherwise required to identify these optimum values.

Supplementary Note 2: Additional discussion on the small deviation between EQE and TMM data at NIR region

It should be noted that the TMM simulation only gives light intensity (power) at certain wavelength. This needs to be changed into photon flux to be comparable with EQE, which is by definition the ratio between incidence photons and generated electrons. Meanwhile, the monochromatic

light of EQE setup we used is actually not composed of a single wavelength but a band with a 5 nm FWHM. We assumed a Gaussian distribution of wavelength within this band and took this into account for the simulation.

Another factor which could be an extra cause for the observed deviation but is not qualitatively considered here is the incidence angle, which is set to 0 degree in the simulation. However, the incident light from the EQE setup is not collimated but shows a divergence of a small angle.

It should be also noted that, even with low probability, the presence of a thin space charge region existing near the electrode due to high density of trapped charges cannot be excluded. Because if this was the case, increasing bias would not lead to increase of electric field across the device. In this case, further investigation should be done to shed light to exact device physics dominating the device operation but is beyond the scope of this paper.

Supplementary Figures

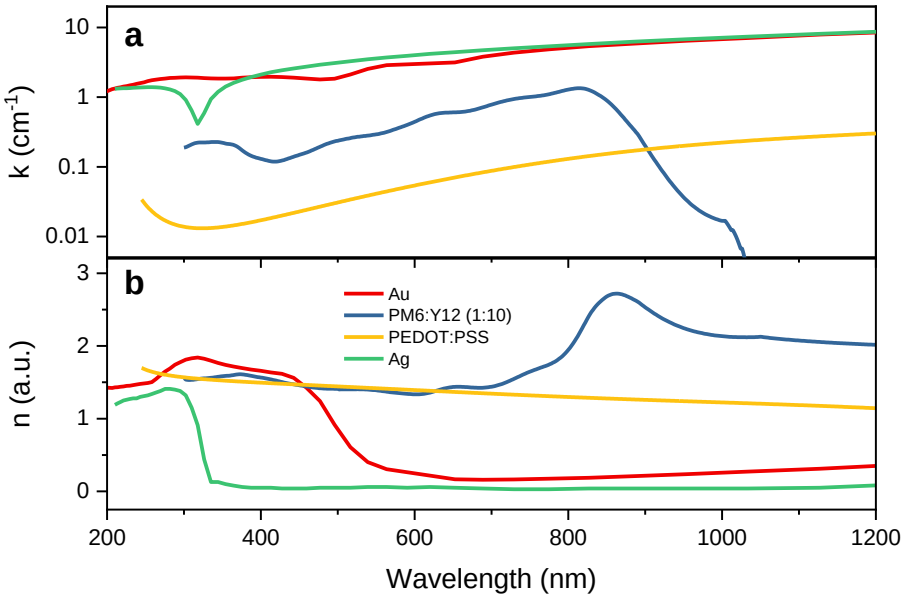

Figure S1. Optical constants used in simulation. All from literature and online database (https://refractiveindex.info/) except the PM6:Y12.

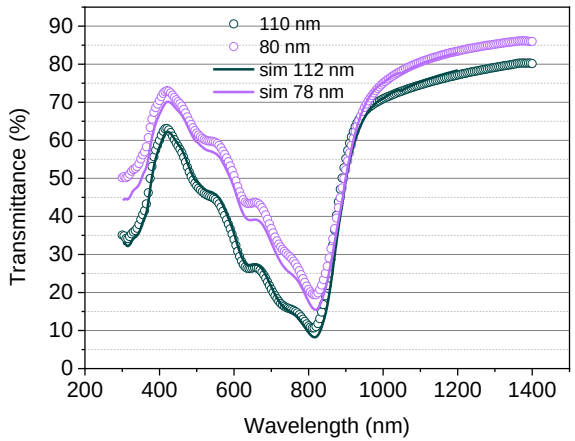

Figure S2. TMM simulated transmittance (lines) vs measured transmittance (circles) of PM6:Y12 photoactive films of 80±2 nm (purple) and 110±2 nm (green) thickness on glass substrate.

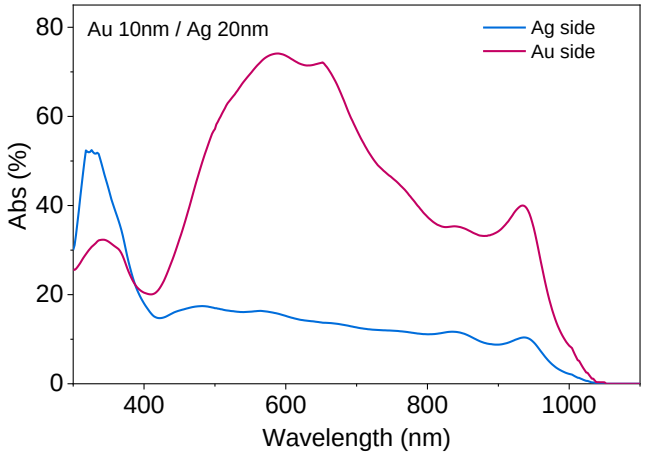

Figure S3. Simulated absorption of photoactive layer with thinner Au (10nm) and Ag (20nm) electrodes but same thickness for active layer show less pronounced peaks in NIR.

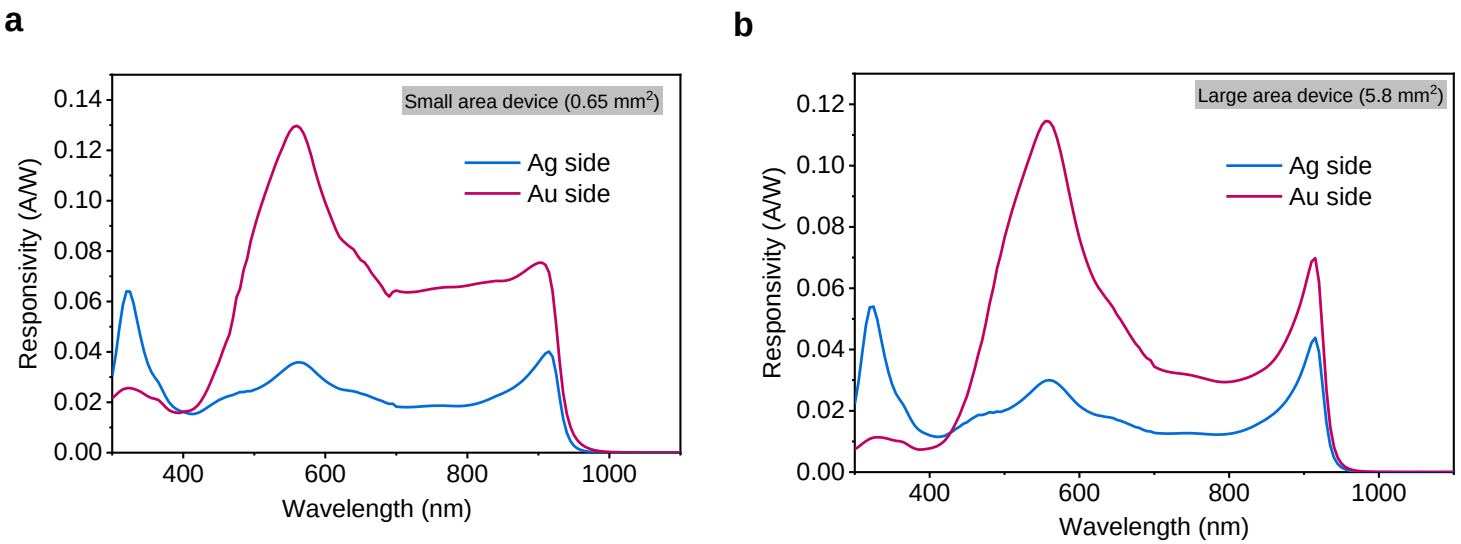

Figure S4. Responsivity of (a) small (0.65 mm^2) and (b) large (5.8 mm^2) device.