Sensitivity and fast response time are desirable parameters for different photosensing applications. However, there is a tradeoff between them, and thus improving one worsens the other. For instance, for a device to be compatible with video-frame-rate imaging, a temporal response in the order of 50 ms is necessary. In the case of LS-NS devices, by decreasing the shunt resistance (e.g., from 200 MΩ to 100 MΩ, 50 MΩ, 1000 KΩ, and 360 KΩ), it is possible to speed up the response time (from 8.0 s to 4.4 s, 2.4 s, 720 ms, and 300 ms, respectively, for an excitation intensity of 0.175 mW/cm^2) as expected. For the same optical power, in the case of ligand-removed LS-NS devices, respectively faster RC decay time constants of 4.7 s, 2.4 s, 1.4 s, 220 ms, and 90 ms were observed. On the other hand, by increasing the shunt resistance (which was set ~200 MΩ in our previous characterizations) would in fact enhance the sensitivity, but this would come at the cost of slowing its temporal response time (due to the increased RC decay time constant). Therefore, the response time of LS-NS devices need to be adjusted in regards to the requirements of a specific application.

The LS-NS devices exhibit reasonably high photosensitivity in comparison to typical NC photodetectors. In the case of LS-NS devices, we calculate the minimum noise equivalent intensity to be 1.94 $\mu W/cm^2$ for the devices with the ligands and 0.443 $\mu W/cm^2$ when ligands are removed, which is comparable to the solution-cast NC photodetectors reported previously [28]. This, in addition to the adjustable response time, makes the LS-NS platform a promising one for photosensing applications.

4. Conclusion

In conclusion, we demonstrated highly efficient, semi-transparent, large-area, solution processable NC-based photosensors employing only single monolayers of NCs. These devices operate on the basis of photogenerated charge accumulation for which there is no need for external biasing (though an external bias can optionally be applied to quickly reset the system if desired). The monolayer of CdTe NCs, placed exactly underneath the metal contact without any transit intervening layer, results in close interaction enabling high photosensitivity and high stability under ambient conditions because of the device architecture sealing the NC monolayer. Furthermore, this device architecture is advantageous in terms of using a small amount of NC materials and making the device transparent with sufficient partial optical absorption. With the ligand removal, we observed a substantial enhancement of ~73% in the light sensitivity and a 3-fold faster response with respect to the case of using ligands. Also, we obtained a significant decrease in the minimum noise equivalent intensity by a factor of 4.4 in the case of ligand-removed NC devices (0.443 $\mu W/cm^2$) compared to the devices without ligand removal (1.94 $\mu W/cm^2$). High photosensitivity, adjustable response time, and memory effect make this LS-NS platform suitable for different optoelectronic applications including UV and visible sensing, e.g., in smart phones. Also, the ability to make large-area LS-NS devices via spray coating at low cost makes them potentially very interesting for smart windows and light-sensitive walls.

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