Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Mesoporous Microbead electrodes for solid state dye sensitized solar cells

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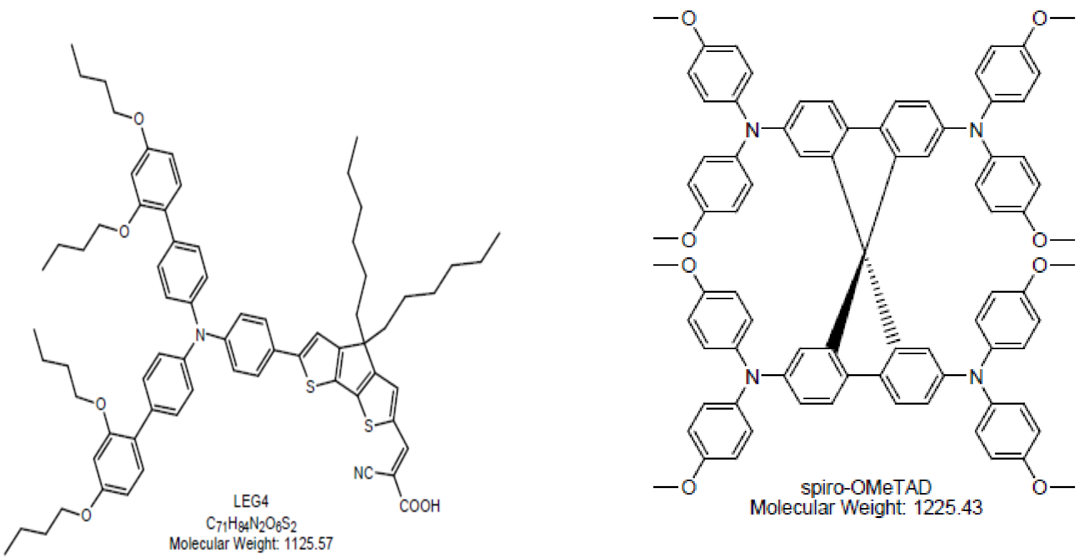


Fig. S.1- Molecular structure of a) LEG4 sensitizer and b) Spiro-OMeTAD.

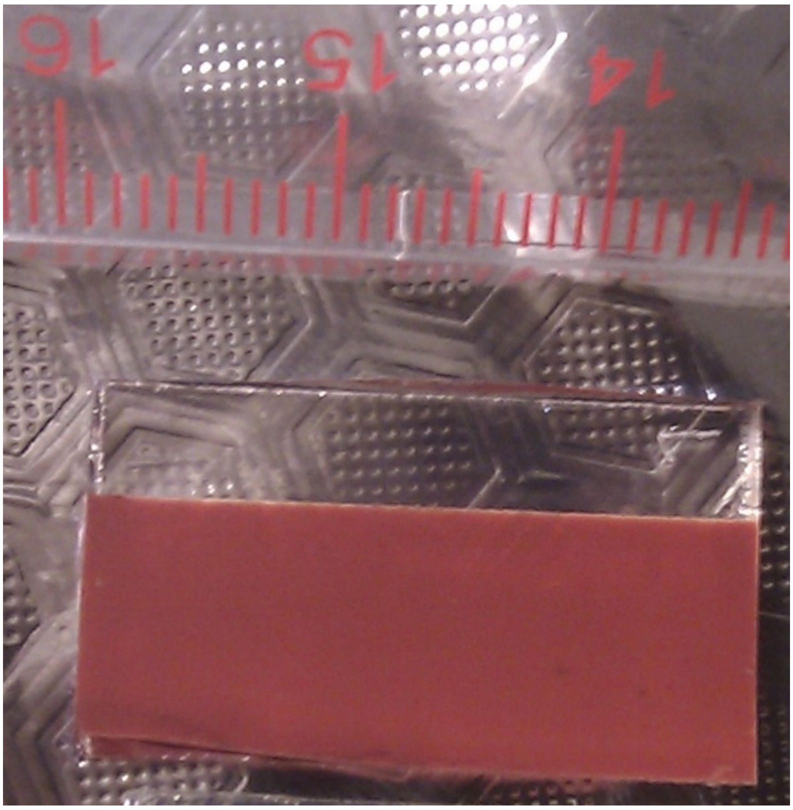


Fig. S.2- Image of MB dyed Working electrode.

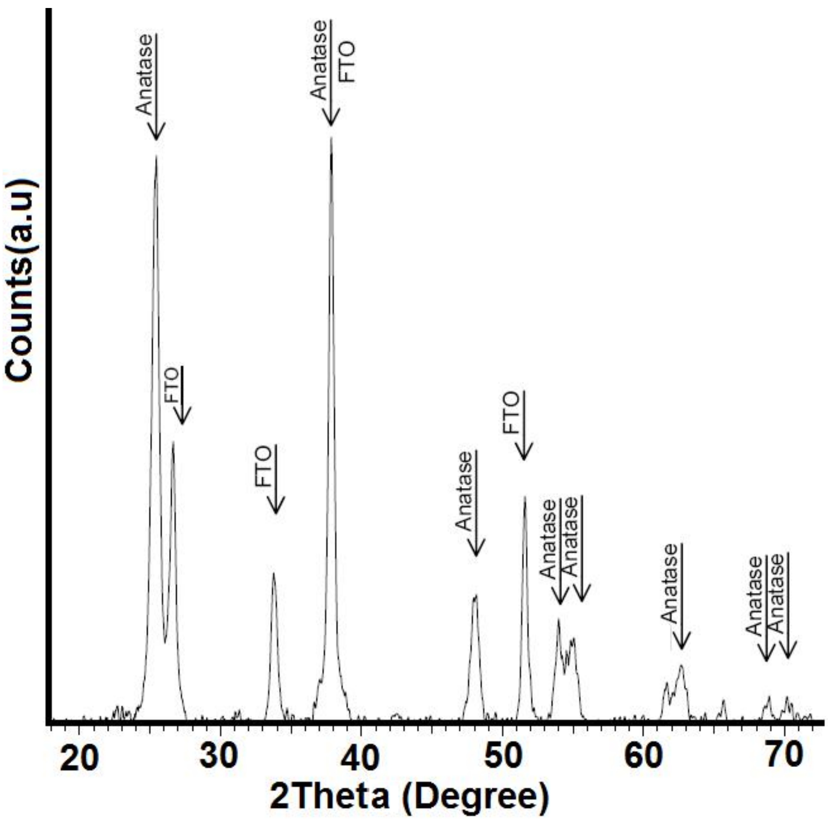


Fig. S3. XRD micrograph of Microbead films.

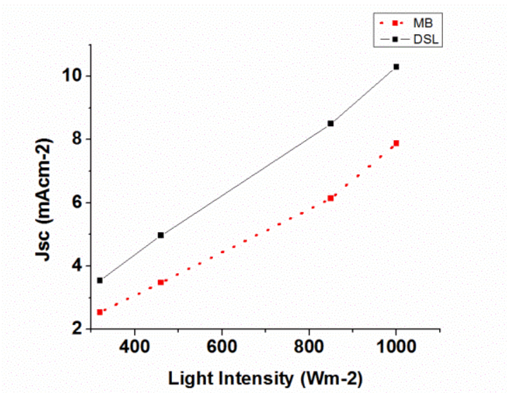


Fig. S4. J_{sc} versus light intensity for fabricated devices.

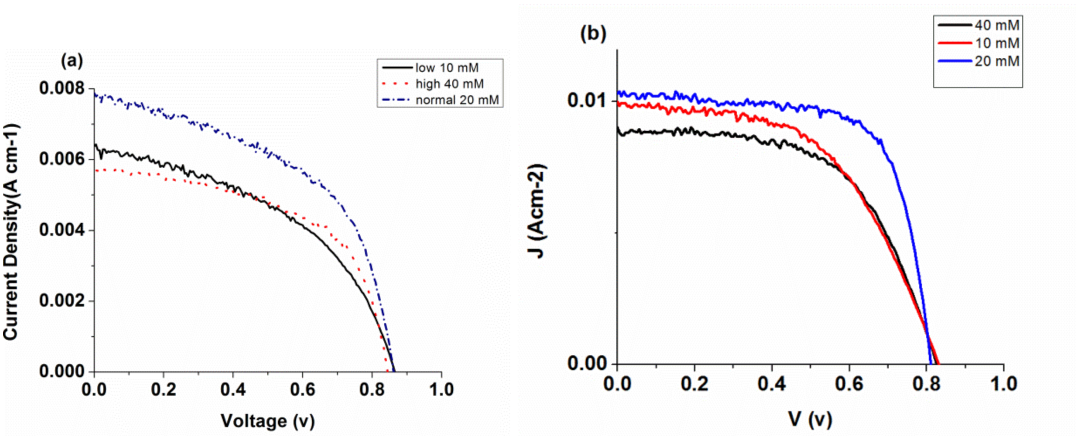


Fig. S5- IV curves of the devices with different Li concentrations for a) MB and b) DSL devices.

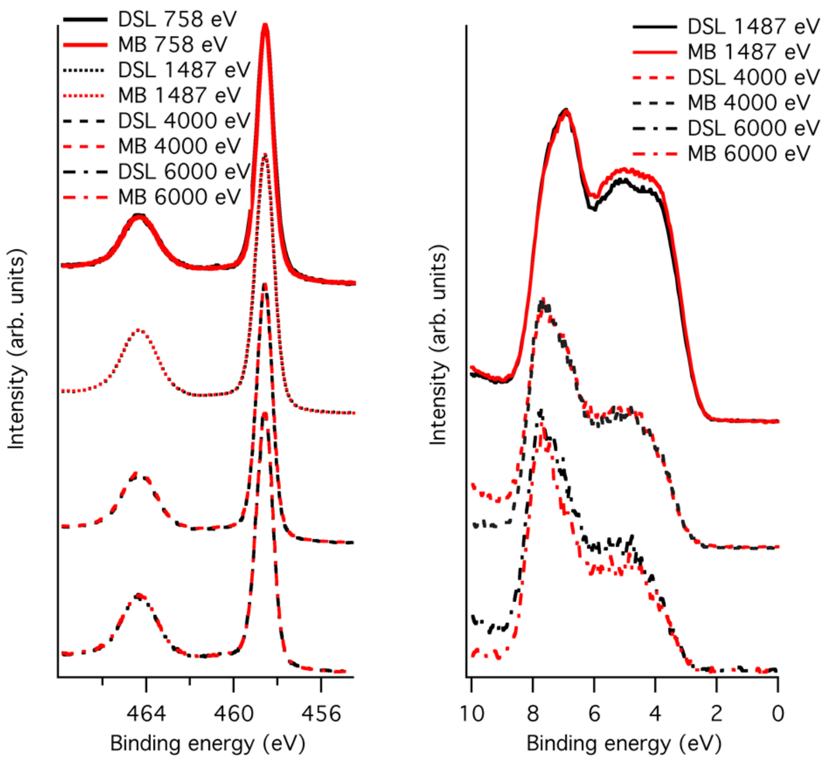


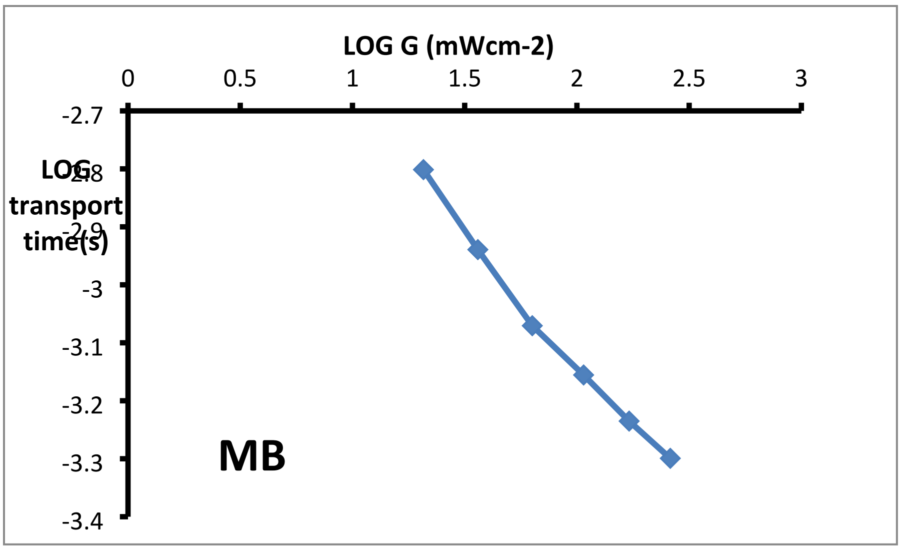
Fig. S6. a) Ti 2p, and b) valence band of the DSL and MB films measured with different photon energies.

S.I Calculation of trap depth density:

J_{sc} versus light intensity were fitted by a line in order to relate the J_{sc} in the transport time experiment to relevant light intensity. Log-log plots of transport time versus light intensity were plotted and fitted by a line. The slope of the line is equal to (kTm^{-1}) [s1] in which k is Boltzmann's constant in eV, T is absolute temperature in Kelvin and m is the trap depth. We should have in mind that SSDSCs have short lifetimes and measured photocurrent response time can be affected by recombination of electrons.

Table S1. Trap depth densities calculated from Fig. s6.

Cell	Slope of line in Fig. S6(kTm^{-1})	Trap depth density (m[meV])
MB	-0.471	49.5
DSL	-0.633	70.3



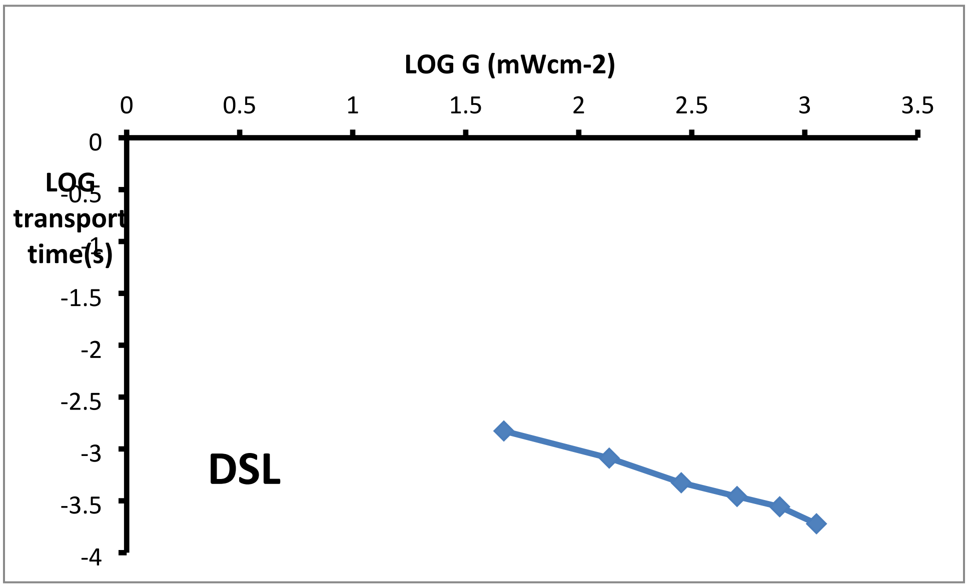


Fig. S7. Log-Log plots of transport time versus light intensity for MB and DSL cells.

S.I I-V curve fitting

We fit the I-V curve of MB and DSL devices using a simple single diode model of Ref s2 [s2]. **Fig. S8.a** Shows the measured I-V and the fitted curves. Shunt conductance and series resistance were 0.5E-3 ohm and 1.7 ohm for DSL device and 3E-3 and 1.7 ohm for the MB devices respectively. We explain the poor fill factor of MB device by the lower shunt resistance. Possible explanation of poor shunt resistance can be explained by the absence of spiro capping layer in the thick MB layer (see Fig. 2 of main text) and possible contact of silver with microbead particles which can cause high recombination rate.

Using graphite as back contact (see below) and comparison of graphite with silver back contact revealed more information about the device shunt resistance. **Fig. S8.b** shows the measured and fitted I-V curves for the typical device with silver and graphite back contacts. Shunt conductance were 3E-3 ohm and 1.7E-3 ohm-1 for silver and graphite devices respectively. Poor contact between graphite and spiro/MB layer decrease the shunt conductance about 2 times. Short circuit current is also decreases by graphite electrode. This is an indication of high recombination rate at the interface of silver and spiro/MB layer.

Lower light scattering and worse contact resistance are possible causes for lower current of device with graphite back contact.

Graphite back contact was applied to devise in very simple way. A printed black-tape mask was placed on the FTO glass and inside the mask was filled by the graphite powder (grain size of 100nm). It was clamped to another glass for 5 seconds and afterward excess carbon cleaned from surrounding of the mask. Finally it was applied to the top of the device and connected by two parallel clamps. Top contact can get from FTO. Contact of graphite and spiro/MB film is poor because of grain size of carbon particles.

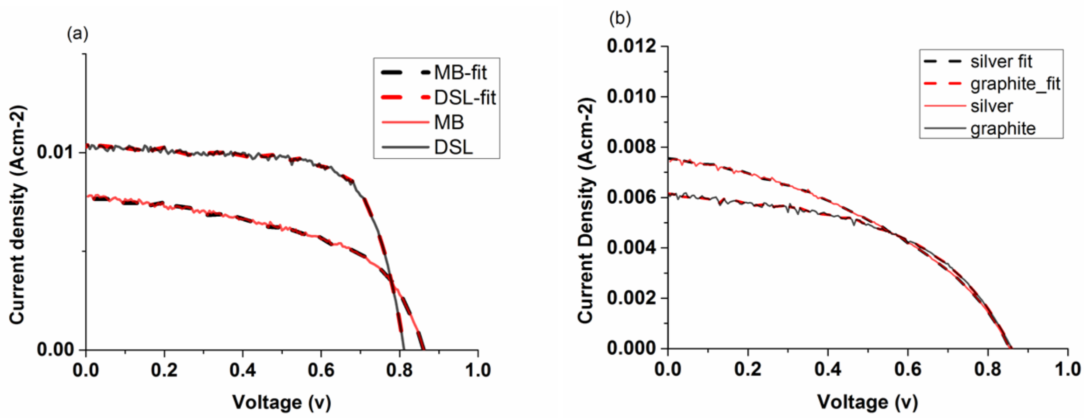


Fig. S8. Measured and fitted I-V curve for the a) MB and DSL device presented in main article. b) silver and graphite devices presented in supporting information.

S.III Statistics of the device efficiency

The active area of the mask is small compared to active area of the cell. Each substrate (figure S.2 of supporting information) has dimensions 0f 2.4 cm times 1.5 cm in which 5 mm times 2.4 cm is the real active area for FTO/blocking layer/TiO2-dye/spiro. On each substrate there are four silver contacts (5 times 5 mm) representing four devices for each substrate. For any single device, moving the mask in between the device active area (covered with silver) does not change the efficiency. Here is statistical data for optimized devices with high efficiency: totally 12 devices have been fabricated.

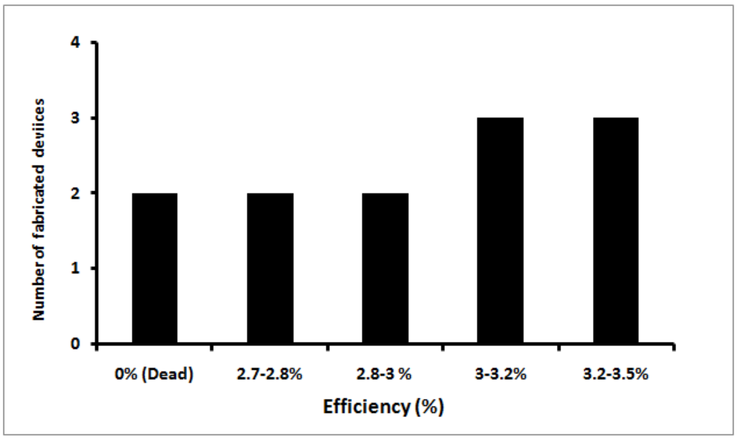


Figure S9- Number of fabricated devices versus efficiency.

References

[s1] G. Boschloo and Anders Hagfeldt, J. Phys. Chem. B. , 109, 12093, 2005.

[s2] model of program