Aerosol Jet Printed Silver Nanowires as Electrodes in organic solar cell devices

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Abstract: Aerosol jet printing (AJP) stands out as a scalable deposition technique for digital optoelectronic manufacturing, particularly in the domain of organic photovoltaic (OPV) devices for indoors applications. Its features, such as non-contact deposition, absence of post treatment and the ability to achieve high-resolution 3D pattern printing using functional nanomaterial inks, have positioned AJP as a promising method for the development of fully solution OPV devices. In this study, we investigated the use of ultrasonic (uAJP) and pneumatic (pAJP) atomization principles to precisely deposit Silver Nanowires (AgNW) inks as Top Electrode Layer (TEL) onto OPV devices. Employing HTS methodologies, we fabricated the OPV stack up to the hole transport layer (HTL) based on an inverted structure. Subsequently, various deposition techniques were involved for comparative evaluation, including spin-coating (SC), blade-coating (BC), uAJP and pAJP of the AgNW inks as well as thermal evaporation (TEvap) of Ag. We further analyzed the thickness and morphology of the device's top electrodes with uAJP-deposited AgNW inks employing SEM, demonstrating that the AgNW ink formed a compact layer, effectively serving as the TEL within the OPV device. Combining HTS setups and AJP deposition methods, we demonstrated automated and solution-processed OPV devices with an average power conversion efficiency (PCE) of 6.3 % and 7.9 % over an active layer of 0.0232 cm2, which is the highest values reported so far for OPV devices with uAJP and pAJP AgNW ink as top electrodes, respectively.

AJP working principles

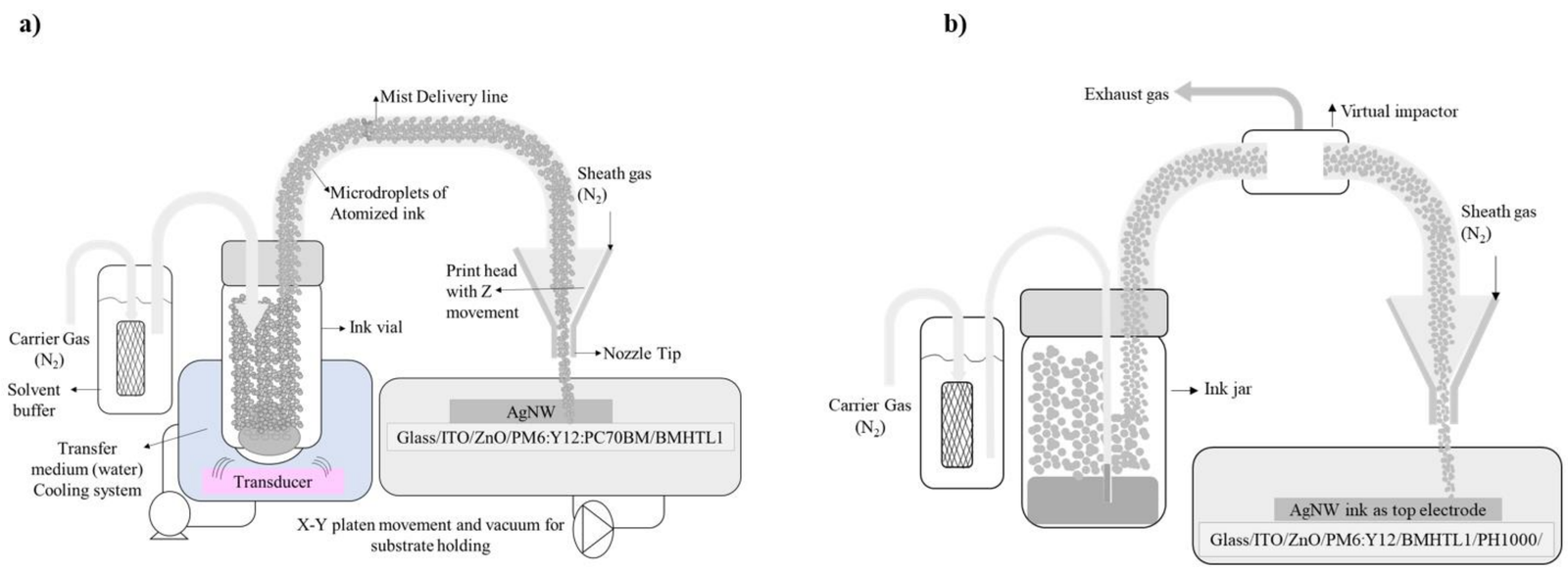
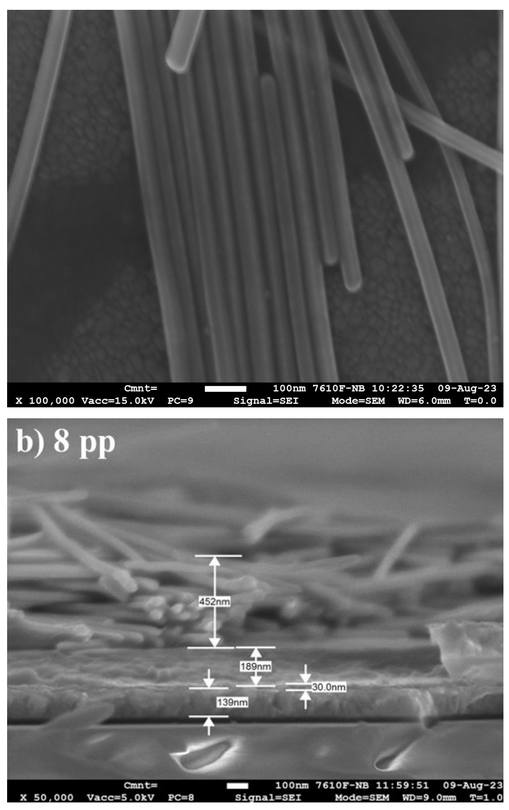


Figure 1. Aerosol Jet printing setups a) uAJP and b) pAJP atomization principles, for AgNW ink printing the top electrode layer in OPV devices with ITO/ZnO/PM6:Y12:PC70BM/BMHTL1/Ag NW structure

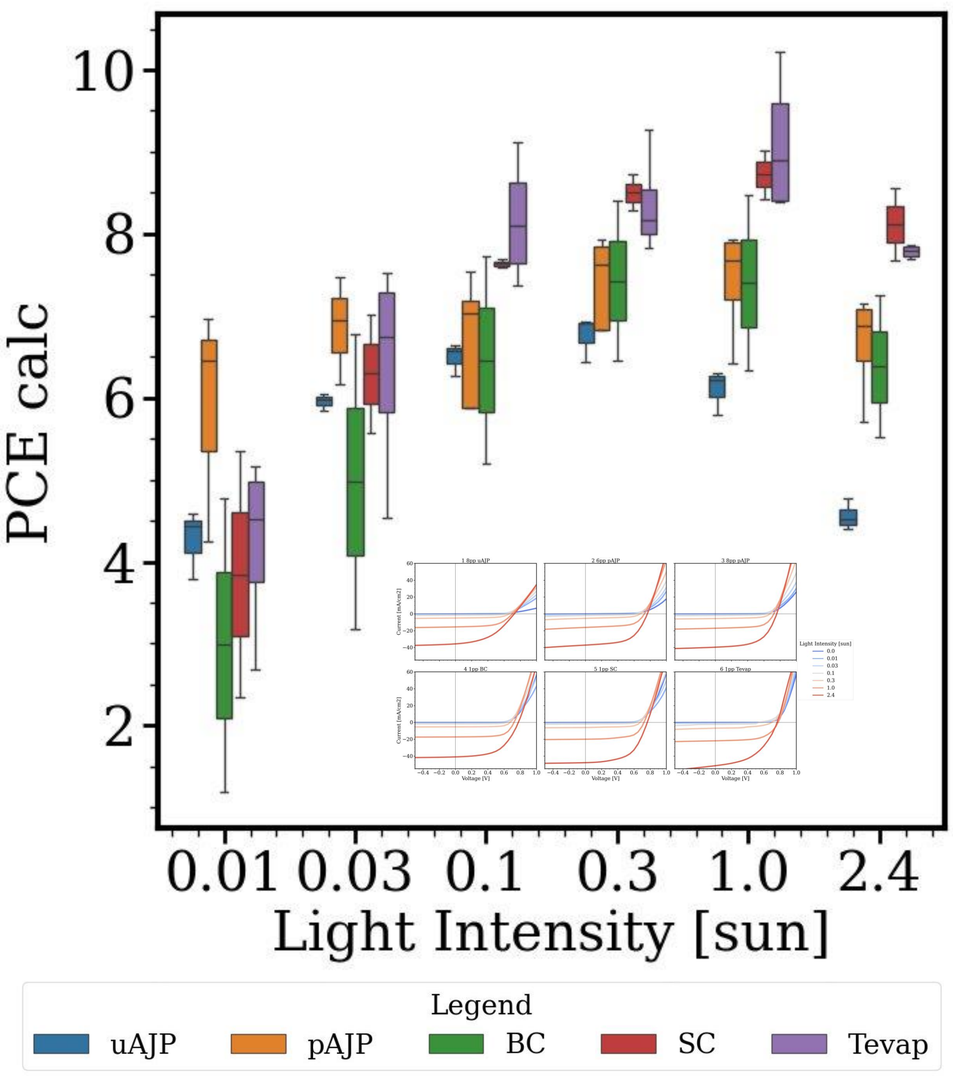
SEM characterization

Figure 2. Top view (up) and cross-section (down) SEM Images of E2X AgNW ink as top electrode.



OPV devices Performances

Figure 3. PCE calc in [%] under different light intensities of OPV devices with spin-coated (SC), blade-coated (BC), pneumatic-Aerosol-Jet-Printed (pAJP), ultrasonic-Aerosol-Jet-Printed (uAJP) of E2X AgNW ink, as well as thermall-evaporation (TEvap) of Ag as Top Electrode Layer (TEL) in OPV devices with ITO/ZnO/PM6:Y12/BMHTL1/PH1000/AgNWorAg structure.



Highlights

- Solution process, automated and inverted organic photovoltaic devices were obtained with help of Spinbot, AMANDA, AJ300 with binary and ternary active l ayers for indoors and outdoors applications.
- In OPV devices, this is the first and highest PCE reached so far with uAJP AgNW ink as top electrodes.

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