Chemistry of mist deposition of organic polymer
PEDOT:PSS on crystalline Si

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Chemical mist deposition (CMD) of poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) was investigated with cavitation frequency $f$, solvent, flow rate of nitrogen, substrate temperature $T_s$, and substrate dc bias $V_s$ as variables for efficient PEDOT:PSS/crystalline (c-)Si heterojunction solar cells (Fig. 1). The high-speed camera and differential mobility analysis characterizations revealed that average size and flux of PEDOT:PSS mist depend on $f$, solvent, and $V_s$. The size distribution of mist particles including EG/DI water cosolvent is also shown at three different $V_s$ of 0, 1.5, and 5 kV for a $f$ of 3 MHz (Fig. 2). The size distribution of EG/DI water mist without PEDOT:PSS is also shown at the bottom. A peak maximum shifted from 300-350 to 20-30 nm with a narrow band width of ~150 nm for PEDOT:PSS solution, whose maximum number density increased significantly up to 8000/cc with increasing $V_s$. On the other hand, for EG/water cosolvent mist alone, the peak maximum was observed at a 72.3 nm with a number density of ~700/cc and a band width of ~160 nm and it decreased markedly with increasing $V_s$. These findings were not observed for PEDOT:PSS/EG/DI water mist. In addition, the Mie scattering image of PEDOT:PSS mist under white bias light was not observed at $V_s$ above 5 kV, because the average size of mist became smaller. These results imply that most of solvent is solvated in PEDOT:PSS molecule and/or solvent is vaporized. Thus, higher $f$ and $V_s$ generate preferentially fine mist particle with a narrower band width. Film deposition occurred when $V_s$ was impressed on positive to a c-Si substrate at a $T_s$ of 30-40°C, whereas no deposition of films occurred on negative, implying that negatively charged mist mainly provide the film deposition. The uniform deposition of PEDOT:PSS films occurred on textured c-Si(100) substrate by adjusting $T_s$ and $V_s$. The adhesion of CMD PEDOT:PSS to c-Si enhanced by $V_s$ conspicuously compared to that of spin-coated film. The CMD PEDOT:PSS/c-Si solar cell devices on textured c-Si(100) exhibited a $\eta$ of 11.0% with the better uniformity of the solar cell parameters. Furthermore, $\eta$ increased to 12.5% with a $J_{sc}$ of 35.6 mA/cm$^2$, a $V_{oc}$ of 0.53 V, and a $FF$ of 0.67 with an antireflection (AR) coating layer of 20-nm-thick CMD molybdenum oxide MoO$_3$ (n= 2.1) using negatively charged mist of 0.1 wt% 12 Molybdo (VI) phosphoric acid n-Hydrate H$_3$(PMo$_{12}$O$_{40}$)·nH$_2$O in methanol. CMD. These findings suggest that the CMD with negatively charged mist has a great potential for the uniform deposition of organic and inorganic on textured c-Si substrate by adjusting $T_s$ and $V_s$.

**Keywords:** C-Si/PEDOT:PSS, solar cells, Mist deposition, growth kinetics

![Fig. 1 Schematic of CMD](image1)

![Fig. 2 Size distribution of mist at different $V_s$](image2)