Printable Graphene - Silver Nanowire Hybrids for Foldable Organic Light Emitting Diodes

Byung Doo Chin, Sung Min Jo, Ohyoung Kim, Jae-Soo Yang

Dankook University, 152 Jukjeon-ro, Yongin-City, Korea

bdchin@dankook.ac.kr

Abstract

Foldable and flexible display devices often generate significantly smaller curvature and larger mechanical stress for repeated operation. In this presentation, highly stable and foldable electrodes were fabricated with solution-processed graphene and silver nanowire (AgNW) composites. Neat graphene nano-platelet was dispersed in solvents with appropriate binders or surfactants to formulate a printable graphene inks [1-2]. Both piezoelectric inkjet as well as electro-hydrodynamic (EHD) jet printing were employed for a fabrication of microscale patterns on the foldable substrates such as mineral paper [3] and polyimide. Pattern uniformity and resolution were controlled by the modification of the surface tension via ink formulation as well as surface functionalization of foldable substrates.

Compared with patterned electrodes formed by neat graphene, graphene/ AgNW (30wt% loading of graphene) circuit showed superior performance; decrease of relative conductance for -90° and -180° folding (toward inside direction) was only 5% and 12%. Moreover, the conductance was maintained about 70% of initial value after 1000 cycle of continuous folding (see Fig. 1). However, dispersion of AgNW and graphene mixture in a printable form is complicated, requiring more physical and chemical steps for appropriate solvent formulation. In case of the graphene /AgNW hybrid electrodes, the grain boundaries in graphene are connected by AgNWs (Fig. 2), so that 1.51 ~ 1.75 Ω/sq (10~30wt% graphene loading) was obtained in foldable circuit on the mineral paper (>100 Ω/sq for neat graphene). As the printed electronic devices, thin film transistor and touch sensors with various channel/pattern scale of graphene-based materials were tested, while in case of organic light emitting diode (OLED), top-emitting structure was fabricated for evaluation on the non-transparent foldable paper /polyimide substrates.

References

[1] E. B. Secor, S. Lim, H. Zhang, C. D. Frisbie, L. F. Francis, M. C. Hersam, Adv. Mater. 26 (2014), 4533

[2] E. B. Secor, P. L. Prabhumirashi, K. Puntambekar, M. L. Geier, M. C. Hersam, J. Phys. Chem. Lett. 4 (2013) 1347

[3] S.M. Jo, D. G. Yoon, R. Bail, B. D. Chin, ECS J. Sol. Sta. Sci. and Tech. 5, (2016) R3185

Figures

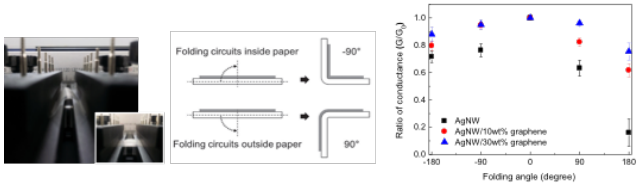

Figure 1: Folding of graphene/AgNW film (-90° inside and +90° outside) and change of relative conductance

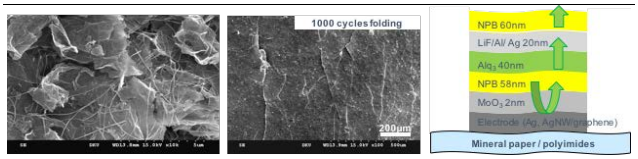

Figure 2: SEM morphology of graphene (30wt%)/AgNW and top-emitting OLED with graphene/AgNW/Ag anode-foldable substrate