Effect of surface roughness on damage generation of roll-transferred graphene

Korea Institute of Machinery and Materials (KIMM) [1], ○Bongkyun Jang[1], Jae-Hyun Kim[1], Kwang-Seop Kim[1], Hak-Joo Lee[1], Byung-Ik Choi[1]

E-mail: jangbk@kimm.re.kr

Graphene transparent electrode on flexible substrates has been regarded as the most promising application of graphene synthesized by chemical vapor deposition (CVD) [1]. Roll-to-roll (R2R) transfer of graphene is an inevitable step for large scale and high throughput manufacturing of the graphene transparent electrode on flexible substrates, where CVD graphene on a catalytic substrate is transferred to a target substrate by means of a carrier film [1-3]. Because the graphene transfer process is realized by a mechanical contact of the carrier film with graphene and its adhesion control, mechanical damages are generated on the graphene during the transfer process, and degrade the electrical performance of the graphene electrode [4]. In this study, key failure mechanisms are identified for the graphene electrode manufactured by the R2R transfer process, and a R2R transfer system to control them is provided based on nip force control module. From scanning electron microscopic observations of mechanical damages on R2R transferred graphene, we found that these damages are correlated with a roughness of the contact surface, which is measured by white light interferometer. The failure mechanisms caused by rough surfaces are identified and their activation mechanics are analyzed using finite element analysis of the deformation of the carrier film under compressive loading of the R2R transfer process. Finally, we demonstrate graphene transfer of 400 mm width at a speed of 1000 mm/min with the R2R transfer machine equipped with an integrated force control module for contact pressure, tension of carrier film, and synchronization of paired rollers. The R2R transferred graphene on a flexible substrate shows high electrical quality and uniformity. This result contributes to overcome the manufacturing hurdles to commercialization of CVD graphene electrode.

[1] J. Ryu, et al., ACS Nano 8(1), p.950-056 (2014).
[2] K. S. Kim, et al., Nature 457, p.706-710 (2009).
[3] S. Bae, et al., Nature Nanotech. 5, p.574-578 (2010).
[4] J. Kang, et al., ACS Nano 6, p.5360-5365 (2012)