N1-P018

Surface energy assisted gecko-inspired dry adhesives

Yudi Rahmawan[1,2], Tae-Il Kim[2], Seong-Jin Kim[1], Kwang-Ryeol Lee[1], Myoung-Woon Moon[1]*, Kahp-Yang Suh[2]*

[1]Interdisciplinary Fusion Technology Division, Korea Institute of Science and Technology, [2]School of echanical and Aerospace Engineering, Seoul National University

We reported the direct effect of intrinsic surface energy of dry adhesive material to the Van der Waals and capillary forces contributions of the total adhesion force in an artificial gecko-inspired adhesion system. To mimic the gecko foot we fabricated tilted nanohairy structures using both lithography and ion beam treatment. The nanohairy structures were replicated from Si wafer mold using UV curable polymeric materials. The control of nanohairs slanting angles was based on the uniform linear argon ion irradiation to the nanohairy polymeric surface. The surface energy was studied utilizing subsequent conventional oxygen ion treatment on the nanohairy structures which resulted in gradient surface energy.

Our shear adhesion test results were found in good agreement with the accepted Van der Waals and capillary forces theory in the gecko adhesion system. Surface energy would give a direct impact to the effective Hamaker constant in Van der Waals force and the filling angle (φ) of water meniscus in capillary force contributions of gecko inspired adhesion system. With the increasing surface energy, the effective Hamaker constant also increased but the filling angle decreased, resulting in a competition between the two forces. Using a simple mathematical model, we compared our experimental results to show the quantitative contributions of Van der Waals and capillary forces in a single adhesion system on both hydrophobic and hydrophilic surfaces. We found that the Van der Waals force contributes about 82.75% and 89.97% to the total adhesion force on hydrophilic and hydrophobic test surfaces, respectively, while the remaining contribution was occupied by capillary force. We also showed that it is possible to design ultrahigh dry adhesive with adhesion strength of more than 10 times higher than apparent gecko adhesion force by controlling the surface energy and the slanting angle induced-contact line of dry adhesive the materials.

Keywords: Nanohairs, surface energy, slanting angle induced-contact line, dry adhesives, ion beam irradiation