Adhesion and frictional characteristics of CVD-grown graphene

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Surface forces such as adhesion and friction forces are crucial in the fabrication and operation of microelectromechanical systems (MEMS) and nanoelectromechanical systems (NEMS) as well as in the nanofabrication processes such as nanoimprint lithography and contact printing process [1]. Various lubricant materials, patterns, and surface treatment processes have been developed for control of the interfacial forces and lubrication between contacting surfaces. We think that graphene can be one of good candidates for lubrication in the small scale because graphene is very thin as a few nanometers and is expected to have good properties of graphite for lubrication. Large-area graphene grown by CVD process can be transferred easily onto various substrates and the transferred graphene would be used as a solid lubricant for contacting surfaces. Recently, it was reported that the surface properties of graphene can be altered [2], and graphene sheets more than five layers show friction forces as small as for bulk graphite [3]. Graphene plates were added to oil in order to increase the lubrication performance of oil [4].

In this study, we characterized the adhesion and frictional properties of CVD-grown graphene to investigate the feasibility of graphene as a thin solid lubricant. CVD-grown graphene has a great merit as a surface coating because of its excellent scalability and transferability. The graphene was synthesized on Cu foil and Ni film by chemical vapor deposition (CVD) process and transferred on SiO2/Si substrate by a wet transfer method [5,6]. Adhesion and friction tests were performed by a home-built microtribometer to investigate the adhesion and frictional characteristics of the graphene in microscale.

Figure 1 shows optical images of Cu-grown graphene and Ni-grown graphene on SiO_2/Si substrate. The optical image of each graphene film shows clear contrast between areas with different numbers of graphene layers. To investigate the adhesion properties of the graphene, the adhesion test was performed using microtribometer. Figure 2 shows the pull-off force measured by microtribometer. In microscale contacts, the graphene reduce the pull-off force significantly. Figure 3 shows the frictional characteristics of graphene films. The results show that the graphene effectively reduced friction force. The Ni-grown graphene on SiO_2 shows relatively durable and low friction coefficient compared to the Cu-grown graphene on SiO_2, In summary, the CVD-grown graphene is so effective to reduce the adhesion and friction forces, and have strong potential to be used as a thin solid lubricant.

References

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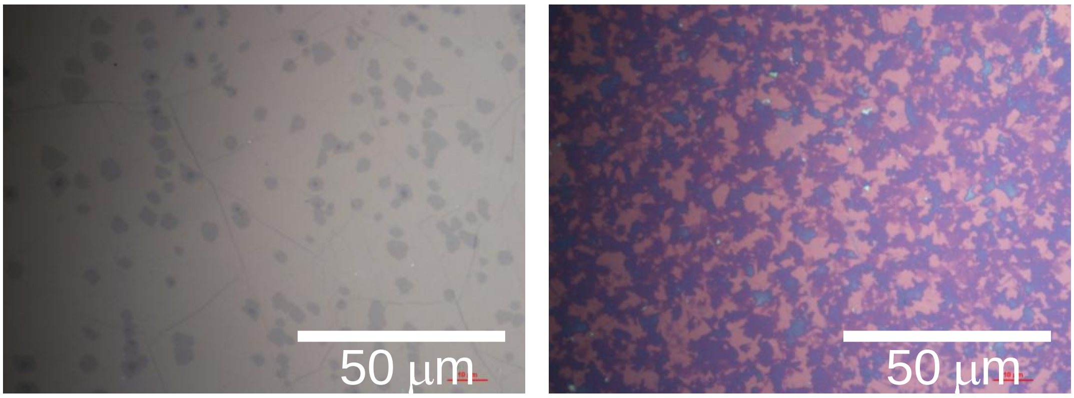
Figures



(a) (b)

Figure 1. Optical micrograph of the graphene films transferred on SiO2/Si substrate.

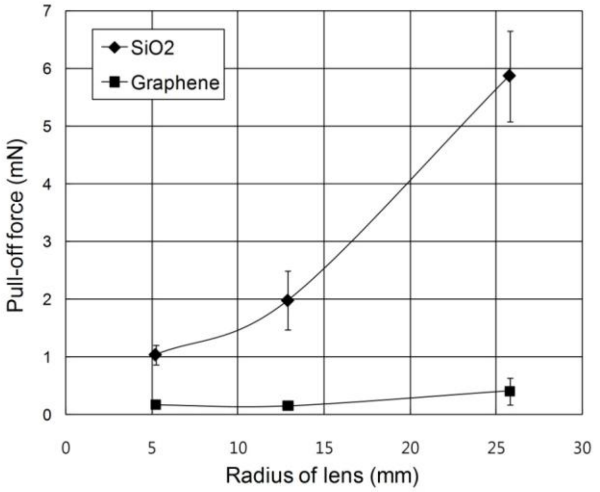


Figure 2. Pull-off force on the graphene samples measured by microtribometer.

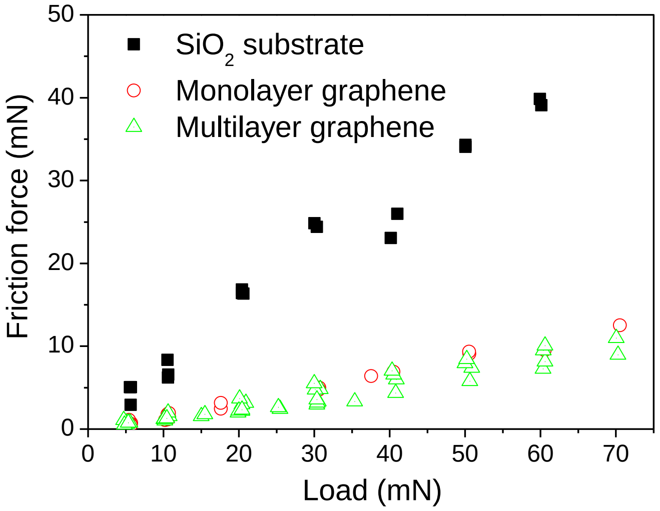


Figure 3. Friction force as a function of load for graphene films.