Jongbeom Choi
Nana Okimura[1], Nobuhisa Ata[1], Wataru Nakayama, Takatoshi Yamada[2], Naoto Ohtake[1], Hiroki Akasaka[1]
[1]Tokyo Institute of Technology, Meguro-ku, Tokyo, Japan, [2]National Institute of Advanced Industrial Science and Technology, Meguro-ku, Tokyo, Japan

choi.j.ah@m.titech.ac.jp

Fabrication of Graphene – Copper composite films by Cold Spray Technique

Cold spray technique has attracted attention from a lot of fields because it has a lower gas temperature compared with other thermal spray techniques such as plasma arc spray. This low temperature is due to the physical deposition mechanism without heating that its deposition mechanism is mainly plastic deformation at the particle collision with a substrate. This deposition mechanism is realized acceleration of particles up to supersonic speed by the use of De laval nozzle [1]. The accelerated particles undergo plastic deformation during the collide with the substrate, and deposited on the substrate. According to the report of Assadi et al, a bonding mechanism is associated with adiabatic shear instability [2]. In this, particle-substrate or particle-particle suffer localized shear deformation during a collision, and bring the metallic bonding of a particle to the substrate or particle. Consequently, these features give cold spray technique advantages of low temperature deposition.

Graphene is an allotrope of carbon in the form of a two-dimensional, atomic-scale, hexagonal lattice in which one atom forms each vertex. Its high heat and electrical conductivity and low friction coefficient are well known, and many researchers reported the reinforced metal matrix composites to introduce these properties into the metal. Although the graphene starts to be oxidized at 1073 K under atmospheric condition [3], it is considered that the relatively low temperature of the cold spray technique allows the graphene to deposit as metal based graphene composite films.

In this study, we conducted a deposition of 0.5 wt.% graphene-copper composite using the cold spray technique. Cu particles with 20 μm in diameter and graphene were mixed by coffee mill. Figure 1 shows the schematic diagram of cold spray. The mixed particles with graphene was introduced to powder feeder in cold spray system. Substrate was A1050 aluminum plate which was processed sandblasting by #46 white alumina, and was placed at 12 mm from nozzle. The condition for gas temperature and pressure were 723 K and 600 kPa, respectively.

The Cu based graphene composite with approximately 290 μm in thickness was deposited on an Al substrate. In Raman spectra as shown in Figure 2, graphitic and disorder bands were detected which means containing graphene in the Cu film. By ball on disk test as tribological test as shown in Figure 3, the friction coefficient was reduced by graphene introduction into Cu from 0.52 to 0.42 because the graphene in film behaved as a solid lubricant.

References

[1] Papyrin, Anatolii, et al, cold spray technology, Elsevier. 2006
[2] Assadi H, Gartner F, Stoltenhoff T, Kreye H, Acta Mater, 51 (2003) 4379-4394
[3] E. A. Gurlbransen, K. F. Andrew, F. A. Brassart, J. electrochem. Soc., 6 (1963) 476-483

Figures
Cold spray

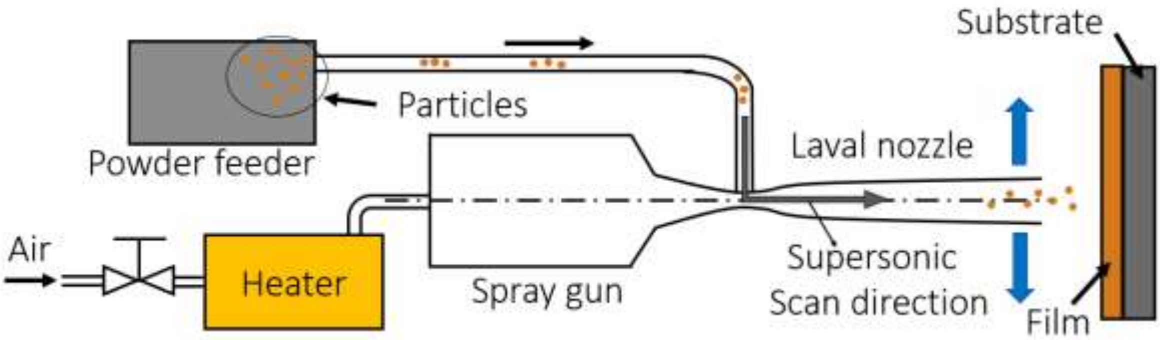

Figure 1: Scheme of Cold spray process

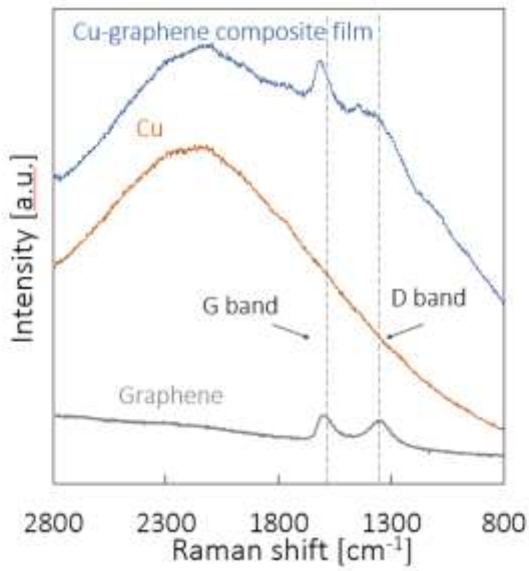

Figure 2: Raman spectra, blue line/Cu-Graphene composite film, orange line/Cu composite film, and gray line/Graphene

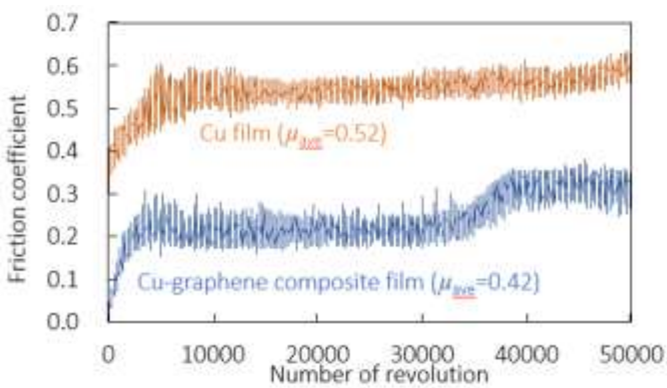

Figure 3: Results of ball on disk test, during the test under 1.0 N, 400 rpm