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Nano carbon contained composite film fabricated by cold spray technique

Nano carbon has remarkable properties such as mechanical, electrical, and thermal properties. For example, graphene and carbon nano tube (CNT) have high electrical conductivity and low friction coefficient [1]. Hence it is expected that introduction of nano carbon materials into composite materials would improve the properties. To obtain such composite film, it is necessary to fabricate in lower than their decomposition temperature and that of nano carbon materials is approximately 400~800 ℃ [2].

In this research, we focused on cold spray (CS) technique to obtain the nano carbon contained composite films. Cold spray is the one of the thermal spray technologies, and is characterized in that the temperature is lower than 1000℃. In the CS technique, the particles are accelerated by supersonic flow up to supersonic velocity and collide with a substrate [3]. In this collision, since plastic deformation occurs at the interface of the particle and substrate, the particles are deposited as film. Thus, thick films such as “mm” can be obtained by CS technique without applying of high temperature. In this study, nano carbon contained composite films were deposited from the mixture powder of matrix and nano carbon materials by CS technique.

As source materials, Cu particles with a mean diameter of 20 um (Cu-HWQ-20: Fukuda Metal Foil & Powder Co., Ltd.) and graphene powder (900561: Sigma-Aldrich Co. LLC) were mixed at the weight ratio of 200:1 by two types of mixing method. In mixing process, coffee mill was used as mechanical stirrering method. And mixture powder was stirrered in ethanol as solution stirrering process for enhancement of adhension between nano carbon and copper particles by solution. These methods were named in this study as “mixer” and “stirrer”, respectively. Using these two kinds of Cu-graphene mixture powder, Cu-graphene composite films were fabricated by CS technique. Figure 1 shows schematic diagram of CS process. Advanced cold gas system (Medicoat Co., Ltd.) based on a DIMET 412-K cold spray system (TEIN TC Co., Ltd.) was used. A1050 aluminum plates whose surface were processed by sand blast with alumina (#46, Fuji Manufacturing Co., Ltd.) were used as substrates. CS deposition condition is as shown in Table 1, and air was used as acceleration gas to obtain Cu-graphene composite film.

Nano carbon contained composite films could be fabricated from both particle mixtures. Figure 2 shows the appearance and thickness of Cu-graphene composite films. In those figures, the orange color area corresponds to the Cu-graphene composite film. Average thickness of “mixer” film was 285 μm and that of “stirrer” film was 120 μm. Graphitic and disorder bands were observed in the Raman spectra as shown in Figure 3, which means graphene introduced into the Cu film. The spectrum of obtained composite film is similar to the spectra which add together from spectra of graphene and copper. It was suggested that heating damage by CS was extremely small and graphene was no decomposition at CS. Hence, these results indicated that the graphene contained copper composite films were obtained by CS technique.

References

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[2] P. Harris, Carbon, 122(2017), pp.504-513
[3] K. Sakaki, Japan Thermal Spray Society, 47(2010), pp.113-119

Figures

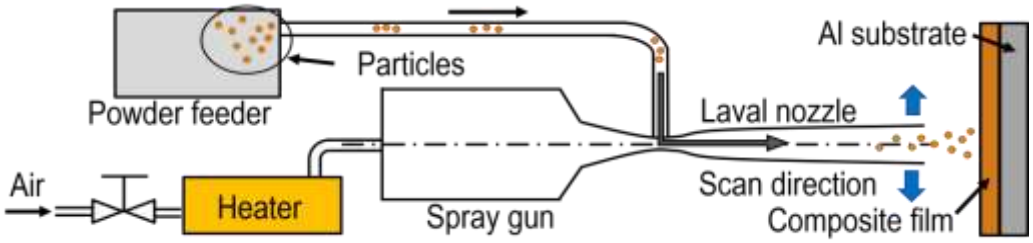

Figure 1: Schematic diagram of cold spray process

Table 1: CS condition

Gas pressure [MPa]	0.6
Gas temperature [K]	723
Gas flow rate [cm^3/min]	340
Number of scan [-]	10
Scan speed [mm/s]	50

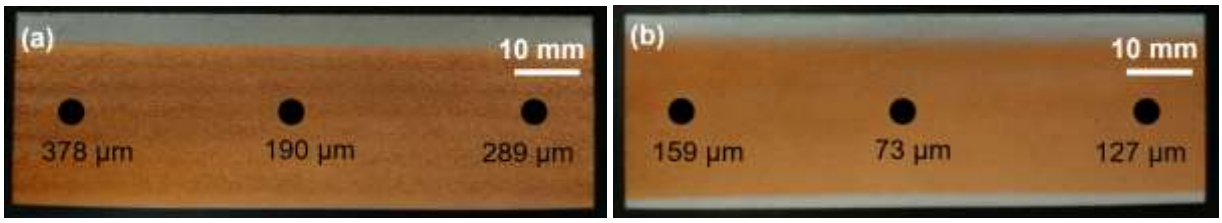

Figure 2: Appearance and thickness of Cu-graphene composite film for (a) mixing process and (b) stirrer process.

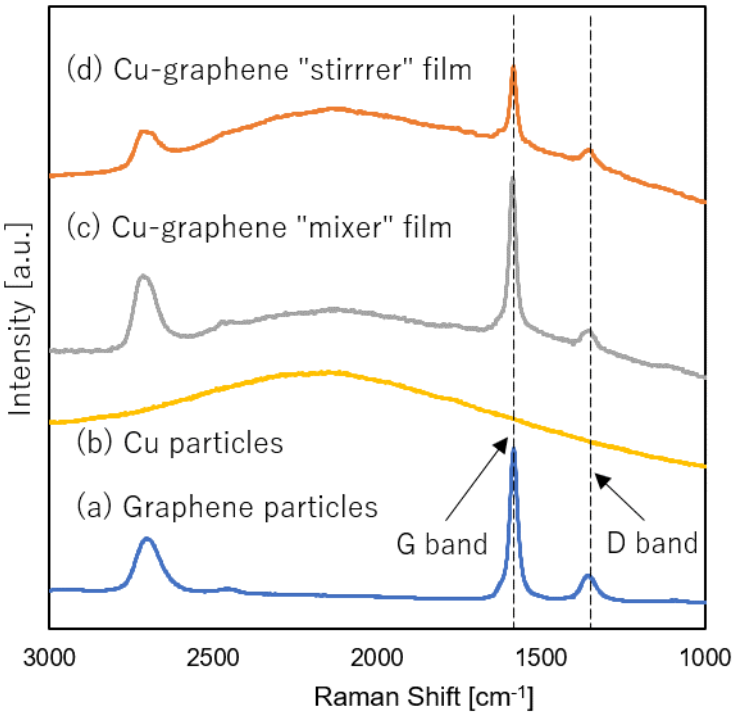

Figure 3: Raman spectra of (a) graphene particles, (b) Cu particles, (c) Cu-graphene “mixer” film, and (d) Cu-graphene “stirrer” film.