Friction Wear Properties between Partially Polished CVD Diamond and Structural Steel

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ABSTRACT

Low friction properties were achieved between partially polished diamond film and structural steel. Diamond films were deposited onto TiC substrates by microwave chemical vapor deposition (MWCVD) using gas mixture of CH_4 and H_2. Deposited diamond film was polished with each other up to surface roughness R_a=0.25 μm. We proposed newly developed pin-on-disk measuring device in order to obtain stable friction coefficient. Friction and wear tests were carried out in the nitrogen atmosphere, the ambient and dry air. In the case of D2, we confirmed the very low and stable friction coefficient μ=0.08 without any lubricants in the ambient atmosphere.

KEYWORDS: CVD, polycrystalline diamonds, low friction, wear

Since the first breakthrough in the chemical vapor deposition diamond films, many research works have been done about their excellent properties such as high hardness, low friction, good thermal conductivity and wide band gap structure[1]. From the viewpoint of industrial applications, the artificial diamond is widely used for the cutting tools. However, the major problems for their practical application lie in the limitation of the substrates and their rather high hardness.

The former problem is being solved by particular technique such as the treatment of the substrate materials[2] and the fabrication of the machinable substrates, Ti_3SiC_2[3]. In order to overcome the latter problem, we developed easily polishable diamond films. The investigated diamond films are categorized as a ballas diamond which was first discovered by Fischer [4]. Related to ballas type diamond films, many research works have already been done[5-7]. Ballas diamond consists of small polycrystalline diamonds connected with each other through amorphous carbon structure, which makes easy to polish diamond surface.

We used the partly polished polycrystalline CVD diamond films as mentioned before for the friction and the wear examination (Fig. 1). The low friction coefficient μ=0.08 has been achieved by a ball-on-disk examination using AISI52100 ball when the diamond film was polished up to Ra=0.05 μm, here R_a is the arithmetic average roughness[8]. But the steel ball is easily worn out and the contact area

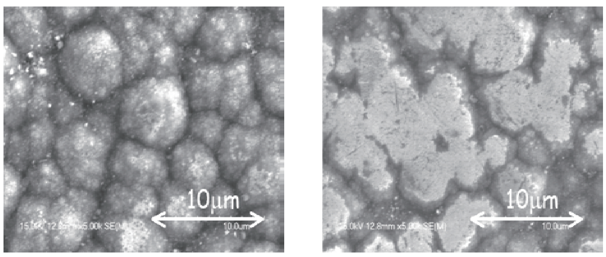

Fig.1. SEM images of as-deposited (top) and partially polished diamond films (bottoms). These films were deposited TiC substrates under the condition of table 1.

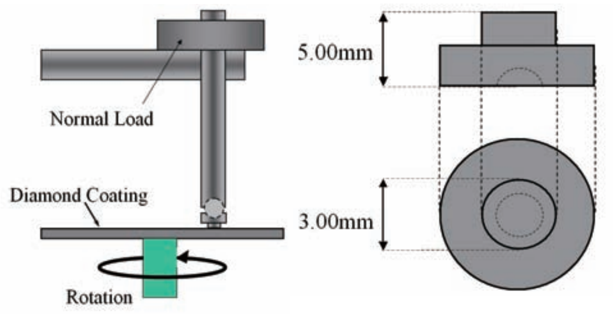

Fig.2 Schematics of pin of metals for friction test

increased remarkably, which cause the unstable behavior during the friction measurement.

In this paper, we focused on the friction properties between the diamond-metal contacts using the newly developed pin-on-disk (Fig. 2) instead of the conventional ball-on-disk. We investigated the relationship between friction coefficient and hardness of metals. Friction and wear test for the four kinds of metals has done in the nitrogen atmosphere, the ambient and dry air. Tested metals are as follows: D2 and AISI440C as the abrasion resistance and high hardness materials, AISI420 and AISI304 as the typical ferrite and austenitic stainless steels.

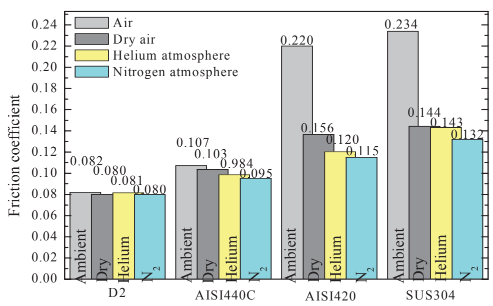

Fig.3. the difference of friction coefficient for each gas atmosphere; Disk : Polished CVD diamond on TiC substrate, *Ra*=0.25 μm, Contact pressure 0.14 MPa, Sliding speed 0.20 m/s, Sliding cycle 20,000 cycles, 25-35 %RH(Air), 1.6 %RH(Dry Air) 15 %RH(N_2), 20-25deg.C

In the case of relatively hard metals, D2 and AISI440C, both the friction coefficient and wear volume are much lower than relatively soft metals, AISI420 and AISI304. We obtained very low (μ=0.08) and stable friction coefficient, and small wear volume (2.1×10^{-9} $mm^3/(Nm)$) from D2 specimens.

We found the friction coefficient is strongly influenced by the level of humidity, and those differences occur notably in the case of relatively soft materials (Fig. 3).

In this paper, it clarified about the material dependence and atmosphere dependence of the friction coefficient of partially polished diamond film. It was shown clearly that the hardness of material and the humidity of the atmosphere are very important for friction properties.

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