Contact mechanics of copper-graphite particulate composites

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Introduction

Copper-graphite particulate composites have excellent thermal/electrical conductivity and the lubrication for solid contact and sliding that stem from a synergetic composite effect of copper and graphite. They have been widely used for sliding components, such as electrical brushes and bearing in their engineering applications. However the wear and the contact processes and mechanisms of the composites under sliding conditions have not been well understood because of their complicated microstructures and nonlinear mechanical behavior. To develop high-performance electrical brushes and mechanical bearings, it may be essentially important to study the microscopic processes and mechanisms of the contact surface deformations of copper-graphite particulate composites.

The indentation test and analysis will be one of the most efficient tools for examining the mechanical properties of contact surface deformations of elastoplastic solids. The major objective of the present study is to establish an indentation test technique for characterizing the contact surface deformations of particulate composites.

Experimental

The powders of electrolytic copper and natural graphite (supplied from Fuji Carbon Mfg. Co.) were used as starting materials to fabricate the particulate composites. The both powders with desired contents are well-mixed, and then uniaxially cold pressed at 294MPa. The green compacts thus obtained are sintered in nitrogen. The particulate composite having various Cu contents ranging from 0 to 100 wt% were made to elucidate the influence of Cu on the mechanical/electrical properties of the composites. The bulk density and the electrical resistivity of the composites with various Cu contents are shown in Fig.1. The electrical resistivity drastically decreases from 300 μΩ・m to 0.04 μΩ・m with the increase in the Cu content from 0% to 100%, whereas the bulk density increases from 2 to 6.6 g/cm^3. The test specimens (6×20mm for the indentation plane and 6mm in thickness) were machined from the sintered plates of the composites. Each indentation plane of test specimens was polished with alumina abrasives (mean grain size of about 0.5 μm) to make a mirror surface prior to indentation tests.

The indentation tests were conducted by a conventional displacement-controlled test machine (Sanwa Kiki Co., Ltd.). The indentation load P was monitored with the precision of ±0.01 N by a load cell (TCLZ100KA, Tokyo Sokki Co., Ltd.). The penetration depth h was measured as the relative displacement between the indenter and the test specimen with the precision of ±0.1 μm by an eddy-current displacement sensor (VS-011, Ono Sokki Co. Ltd.,). The rate of penetration was controlled to be 0.02 mm/min. A spherical indenter (Brinell sphere; R=6.350mm) and a Vickers indenter were used to measure the elastic modulus and the hardness parameters, respectively.

Results and Discussion

The elastic modulus *E*' and the true hardness *H* obtained by the indentation tests are plotted in Fig.2 as the functions of Cu content of the composites. Both of the mechanical parameters of *E*' and *H* increase with the increase in Cu content. It is worthy to note that the elastic modulus and the true hardness increase in rather steep manners at the Cu contents exceeding about 50 wt%. These behaviors may be closely related to the dependence of bulk density on Cu content (see Fig. 1). It was concluded through the present studies that the indentation contact mechanics is useful for examining the mechanical properties of particulate composites. The further details including the relationship between the microstructure and the elasto-plastic deformations will be presented in the poster presentation.

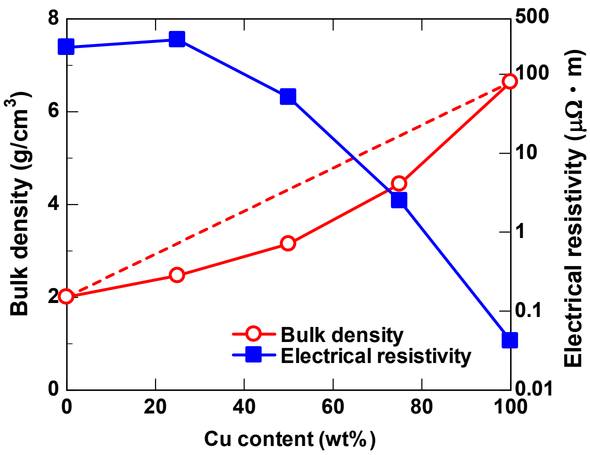

Fig.1 Relationship between Cu contents and bulk density / electric resistivity.

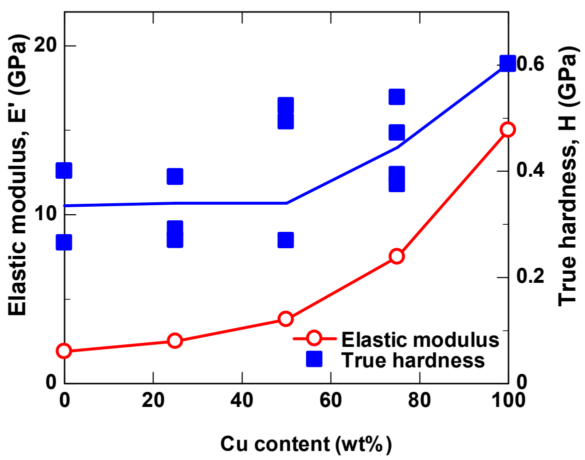

Fig.2 Elastic modulus and true hardness as a function of Cu contents.

Biographical Sketch

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Mr. Takatoshi Futami received his master's degree in 2001 in materials science at Toyohashi University of Technology, and then joined Fuji Carbon Manufacturing Co. He has been developing carbon brush materials at Fuji Carbon MFG,. He is currently a doctor-degree student at Toyohashi University of Technology. His research is focused on the contact mechanics of carbon-metal composite materials and their tribological studies.