Characteristics of Carbonaceous Bipolar Plate with Spherical Natural Graphite for PEMFC

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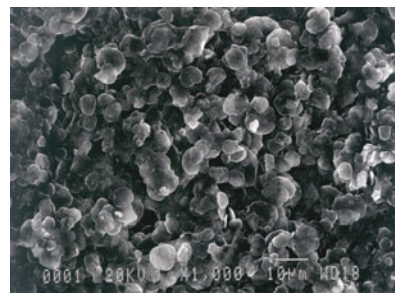
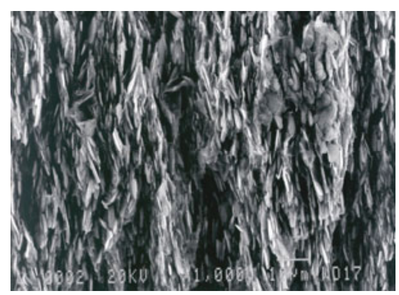
Structural anisotropy of natural graphite compact is one of the most significant obstacles to be removed for practical utilization of carbonaceous bipolar plate. We report electrical anisotropy of natural graphite compacts could be controlled through control of particle shape.

Introduction

Polymer electrolyte membrane fuel cell(PEMFC) is one of the most promising candidates for power sources in next generation. The most expensive and important component is bipolar plate, which is occupied by cost rate of higher than 50%. Production costs for bipolar plate as well as MEA should be lowered for practical commerciallization of PEMFC. Metals and carbon-based inorganics are considered to be appropriate materials in the view point of mass production for bipolar plate in PEMFC. Carbonaceous materials seem to be more close to practical realization, due to superior electrical conductivity and corrosion resistance to metallic ones. However, it is essential to develop the fabrication process for carbonaceous bipolar plate, as simple as possible, compared to rolling process of metal. The most adoptable process may be simple molding of natural graphite with carbonaceous binder by uniaxial pressing at room temperature or elevated temperature. Natural graphite particles are rearranged along applied stress during compaction, as the particles are inherently flake shape. The rearrangement of graphite particles results in structural anisotropy. In general, stacking of flake graphite along the direction of applied stress, as shown in Fig. 1, results in lower electrical conductivity and ILSS along stacking direction. Anisotropy of graphite compact is one of the most significant obstacles to be removed for practical utilization of carbonaceous bipolar plate which consists of natural graphite, because electrical conductivity along stacking direction plays a more important role in performance of PEMFC than that along planar direction. We have tried to fabricate carbonaceous bipolar plate which used natural graphite with spherical shape in order to grade up with isotropic graphite with high density. In this study, we investigated the electrical isotropy of natural graphite compacts with spherical shape to those from conventional flake graphite through uniaxial pressing.



(a) compacted surface



(b) fractured surface

Fig.1 Microstructure of natural graphite compact with mean dia. of <5μm without binder

Experimentals

3 kinds(mean diameter 5, 15, 100 μm) of natural graphite particles with different particle size were chosen to fabricate natural graphite compacts. Phenolic resin(liquid/solid) was also chosen as carbonaceous binder. The graphite powders were compacted under compressive loading of $600 kg_f/cm^2$ without binder to measure the their own inherent electrical anisotropy, respectively and with binder of 10~30parts to measure the general characteristics such as density, 4-point flexural strength, gas permeability, etc. The compacts with/without binder were cured at around 200℃, followed by additional thermal treatment at 300~1000℃ under N_2 atmosphere.

4-probe electrical resistivity for each compacts was measured along 2 directions ; stacking direction(through-plane) and planar direction(in plane). Isotropic factors of the resistivity were expressed as the ratio of through-plane resistivity to in plane resistivity. Microstructure of compacted and fractured surface was also observed by SEM.

Results and discussion

Bipolar plate from natural graphite compacts have several disadvantages to that from isotropic graphite with high density(HDIG), yet, though they have been studied for last decade. Ultimately, It may be the final goal that natural graphite compacts have the possibility to replace isotropic graphite with high density under present utilization as bipolar plates. One of the disadvantages is structural anisotropy due to inherent flake shape of natural graphite. Shape control of graphite particle, therefore, is the most important to fabricate the graphite compacts for bipolar plate with higher density, strength and electrical conductivity. We intended to control the structural anisotropy of natural graphite compacts through shape control of natural graphite powder.

Figure 2 shows the electrical anisotropy of natural graphite compacts in this study, compared to that of commercial HDIG(measured) and press molding compacts(quoted from catalog). The value on each column in graph is the anisotropic ratio of the electrical resistivity for through-plane to that for in plane. It means the compact is isotropic, as the value approaches to unity. It is well known that most of compacts have larger anisotropic value from1.5 to 5.0 than that of HDIG. Especially, the value of flake graphite compact with mean diameter of 100 ㎛ reached to nearly 100, as it were, typical anisotropy, on the other hand, that of spherical graphite compact with mean diameter of 15 ㎛ extremely decreased to 2.7. Effect of bulk density on the resistivity could be neglected, as the bulk density of each compacts was nearly identical(1.8~1.9g/cm^3). Therefore, electrical anisotropy could be improved through control of the natural graphite shape from microstructure comparison for each surface of natural graphite compacts in Fig.1 and Fig.3.

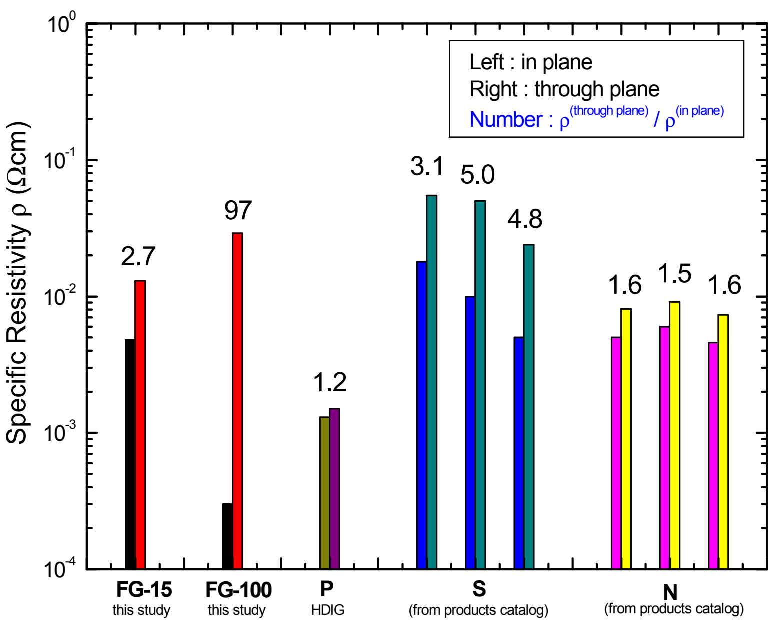
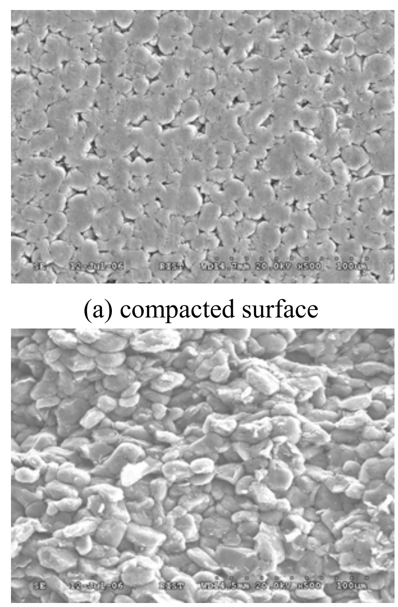


Fig. 2 Anisotropy in electrical resistivity of various carbonaceous bipolar plate



(a) compacted surface

(b) fractured surface

Fig.3 Microstructure of natural graphite compact with mean dia. of <20㎛ without binder

References

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