Fabrication of Highly Ordered Structures Using Anodic Porous Alumina

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Fabrication of highly ordered structures of nanometer dimensions have recently attracted increasing interest because of their utilization for functional devices. For preparing the fine structures, processes based on self-organization of the materials are promising because it yields the fine structures which are difficult to achieve with conventional techniques. In the present report, results of fabrication of highly ordered structures of nanometer dimensions using anodic porous alumina are described.

Anodic porous alumina, which is obtained by anodization of Al in acidic solution, is a typical self-ordered material, and is a candidate for the staring structure of nanofabrication. The recent improvement in the degree of ordering of the anodic porous alumina has increased the attractiveness as a starting structure for nanofabrication [1-4].

For the improvement of the ordering of hole configuration of anodic porous alumina, two types of processes have been studied; naturally occurring long-range ordering[1-4], and ordering with ideally arranged hole configuration formed using anodization of pretextured Al[5].

Naturally occurring long-range ordered anodic porous alumina is obtained under the appropriate anodizing condition. The condition for the long-range ordering is characterized by long period anodization under the constant anodizing voltage condition at the appropriate voltage specific for the anodizing solution.

Pretexturing of Al by nanoindentation using a mold with a ordered convexes, and subsequent anodization generate the anodic porous alumina with ideally ordered hole configuration over the sample. In this process, an array of shallow concaves formed on Al by indentation serves as initiation sites for hole generation in the initial stage of anodization. The pretexturing process using nanoindentation enables the high throughput mass production of ideally ordered hole-arrays of nanometer dimensions, because the mold can be used many times.

Two types of the highly ordered anodic porous alumina have been applied to several nanofabrocation processes. A two-step replication process using ordered anodic porous alumina as a starting structure yields a hole array structure composed of metals and semiconductors[1, 6-8]. In this process, the fabrication of negative-type anodic porous alumina and the subsequent formation of the positive type generates hole arrays of metals and semiconductors with a geometrical structure identical to that of the starting anodic porous alumina. Figure 1 shows SEM micrograph of a typical example of the metal (Ni) nanohole arrays prepared by the two-step replication process. Electrodeposition of metal generates the ideally ordered hole array structure with high aspect ratios. Sol-gel or electrodeposition processes of semiconductor generate the ordered semiconductor array structures [8,9]. Another application of the highly ordered anodic alumina in the replication processes is as a mask for nanofabrication[2].

The processes using highly ordered anodic porous alumina will be useful for the fabrication of several kinds of functional electrodes, photonic crystals[9] or chemical sensors.

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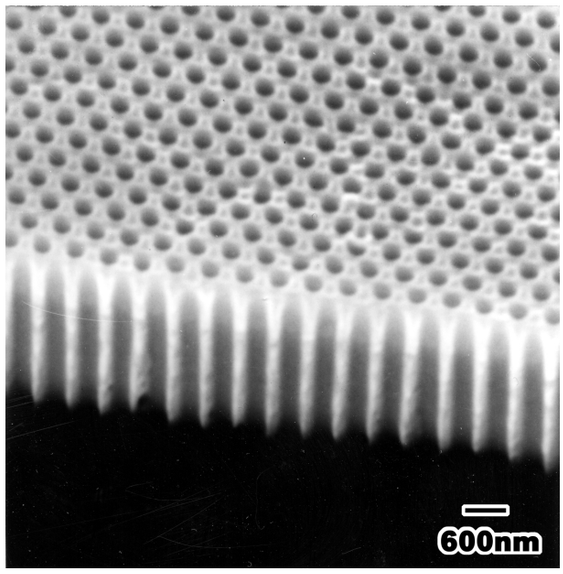

Fig. 1 SEM micrograph of metal nanohole array (Ni) prepared by two-step replication using ideally ordered anodic porous alumina as a starting structure.