Abs. 79, 204th Meeting, © 2003 The Electrochemical Society, Inc.

Optical Properties of Ideally Ordered Metal Hole-Array Membranes Based on Anodic Porous Alumina

Kazuyuki Nishio[1,2], Takashi Yanagishita[1]
and Hideki Masuda[1,2]
[1]Department of Applied Chemistry,
Tokyo Metropolitan University
Hachioji, Tokyo 192-0397, Japan
[2]Kanagawa Academy of Science and Technology
Sagamihara, Kanagawa 229-1131, Japan
masuda-hideki@c.metro-u.ac.jp

The fabrication of ordered fine patterns of nanometer dimensions is of growing importance for preparing various types of nanometer-scale devices, such as electronic, optoelectronic and magnetic devices. For preparing the fine structures, process based on self-organization of materials is promising because it yields ordered fine structures over large areas, which is difficult to achieve with conventional lithographic techniques. Anodic porous alumina, which is formed by anodization of Al in an appropriate acid solution, is a typical self-organized structure with an ordered array of uniform-sized pores. This material is useful as a starting structure for the fabrication of several kinds of devices in nanometer to submicrometer scale because of its ordered hole-array structure.[1,2] In the present work, we describe the fabrication of ordered metal hole-arrays using anodic porous alumina and their optical properties.

Ordered metal hole array structures were prepared using anodic porous alumina as a starting material for replication. A two-step replication process using ordered anodic porous alumina yields a hole array structure composed of metal[1] or semiconductor.[3] In this process, the fabrication of negative-type of anodic porous alumina and the subsequent formation of the positive type generate hole arrays of other materials than alumina with a geometrical structure identical to that of the original anodic porous alumina.

In the present study, ideally ordered anodic porous alumina was used as a starting structure for the replication process because precise control of regularity and dimensions is necessary to study optical properties caused by interactions between the hole-array structure and wavelength of the incident light. Anodic porous alumina with an ideally ordered hole configuration was prepared by anodization of Al with a pretextured pattern.[4] An array of shallow concaves was prepared on Al (99.99% purity) by imprinting using a SiC mold which has an array of hexagonally arranged convexes on the surface.

Figure 1 shows a typical example of the ideally ordered metal (Ni) hole array prepared by the replication process. The size and interval of the holes were 140 and 500nm, respectively. The aspect ratio of the holes was over 7.

Transmission spectra of Ni hole-array membranes showed the band-pass characteristic in the visible range, and cut off incident light of wavelength corresponding to their hole sizes.[5] The optical property of metal hole-array was also dependent on the refractive indices of the media in the holes. Figure 2 shows the relationship between the refractive index of the medium in the holes and wavelength at peak transmittance. The wavelength at the peak linearly increased with increasing the refractive index of the medium in the holes. This result indicates that the refractive index of the medium which fills the holes can be detected based on the optical property of the ideally ordered metal hole-array.

Ideally ordered metal hole-array membrane has potential application in several types of spectro-electrochemical devices, because it senses the change in refractive index of the medium in the holes.

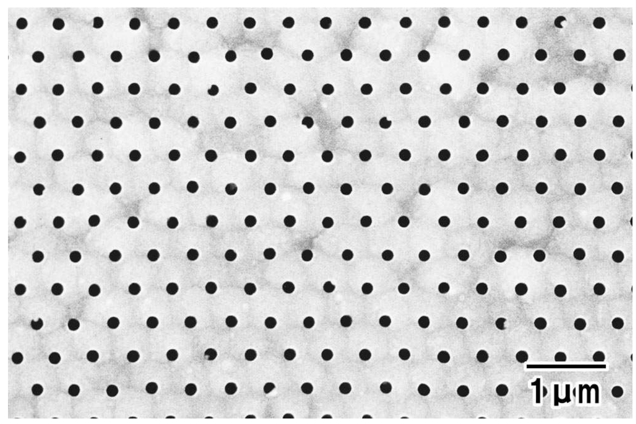

Fig. 1 SEM image of ideally ordered Ni hole array structure prepared by replication of anodic porous alumina.

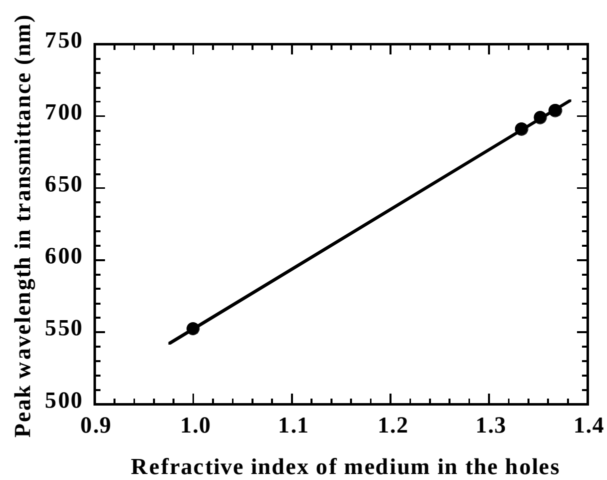

Fig. 2 Relationship between the refractive index of the medium in the holes and wavelength at peak transmittance.

References

1. H. Masuda and K. Fukuda, Science, 268, 1466 (1995).
2. H. Masuda and M. Satoh, Jpn. J. Appl. Phys., **35**, L126 (1996).
3. H. Masuda, K. Nishio, and N. Baba, Jpn. J. Appl. Phys., **31**, L1775 (1992).
4. H. Masuda, H. Yamada, M. Satoh, H. Asoh, M. Nakao, and T. Tamamura, Appl. Phys. Lett., **71**, 2770 (1997)
5. K. Nishio, M. Nakao, A. Yokoo and H. Masuda, Jpn. J. Appl. Phys., **42**, L83 (2003).