

APPROVAL SHEET SUBMISSION

OPTICAL CHARACTERIZATION OF A PHOTONIC CRYSTAL COMPOSED OF METAL-DIELECTRIC MULTILAYERS

By

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To

MY PARENTS

MY BROTHERS
&
SISTERS

MY WIFE

MY KIDS
ALAA
&
ALBARAA

TABLE OF CONTENTS

Approval Sheet Submission.....	i
Acknowledgments.....	ii
Table of Contents.....	iv
List of Figures.....	vi
List of Tables.....	xii
Publications.....	xiii
Abstract.....	xiv

Chapter One: General Introduction

1.1. Introduction.....	1
1.2. Thesis organization.....	3
1.3. Photonic crystals.....	4
1.4. History of photonic crystals.....	7
1.5. Fabrication challenges.....	11
1.6. Photonic band gap.....	12
1.7. Applications.....	14
1.8. Surface Plasmon (SP).....	17
1.9. Aim of the work.....	21

Chapter Two: Fabrication and Optical Characterization of Nanoporous Anodic Alumina Membranes

2.1. Introduction and previous work.....	31
2.2. Template synthesis method.....	38
2.2.1. The aluminum anodizing process.....	38
2.2.2. Aluminum oxide barrier film.....	40
2.2.3. Porous Anodic Alumina (PAA) template synthesis.....	41
2.2.3.1 Parameters influencing self-ordering.....	42
2.2.3.2 Electrochemistry of porous alumina.....	45
2.3. Experiment set-up: Two-step anodization process.....	51
2.4. Results and discussion.....	58
2.4.1. The growth kinetics of alumina films.....	58
2.4.2. Structural properties of PAA membranes.....	59
2.4.2.1. Effect of the second anodization time.....	59
2.4.2.2. Effect of the pore widening time.....	62
2.4.3. Optical properties of PAA membranes.....	65

Chapter Three: Uniform and Reproducible Barrier Layer Removal of Porous Anodic Alumina Membrane

3.1. Introduction	78
3.2. Experimental details	80
3.3. Results and discussion	81
3.3.1. Effect of barrier layer thinning process	81
3.3.2. Effect of cathodic polarization time	83
3.3.3. Effect of pore widening time	86

Chapter Four: Strong Surface Plasmon Resonance of Ordered Gold Nanorods Array Fabricated in Porous Anodic Alumina Template

4.1. Introduction	94
4.2. Experimental details	95
4.3. Results and discussion	97
4.3.1. Au/PAA composite and freestanding Au nanorods array morphologies..	97
4.3.2. Optical properties of Au nanorods /PAA composites.....	99
4.3.2.1. Effect of aspect ratio (AR).....	99
4.3.2.2. Effect of angle of incidence.....	101
4.3.3. Optical properties of freestanding Au nanorods arrays.....	104

Chapter Five: Fabrication and Optical Properties of Porous Anodic Alumina Membranes Uniformly Decorated With Ultra-Thin Porous Gold Nanoparticles Arrays

5.1. Introduction	109
5.2. Sample fabrication and characterization	112
5.3. Numerical Calculations.....	113
5.4. Results and discussion	117
5.4.1. PAA morphology	117
5.4.2. Effect of gold thickness	117
5.4.2.1. PAA-Au coated morphology	117
5.4.2.2. Microscopic analysis	121
5.4.2.3. Optical properties.....	123
5.4.3. Effect of pore diameter (Pore widening time).....	129
5.4.4. Effect of angle of incidence.....	135
5.4.5. Decoration effect.....	138

Chapter Six: Summary and Conclusion.....143

Arabic Abstract.....147

LIST OF FIGURES

Fig.1.1. Schematics of a 1D, 2D and 3D photonic crystal. The colors represent materials with different dielectric indices. The spatial period of the material is called the lattice constant, a .

Fig.1.2. Some of important applications of the photonic crystals.

Fig.2.1. Schematic illustration of an anodizing cell.

Fig.2.2. Schematic cross-sections of a PAA membrane; D_{int} = interpore distance, D_p = pore diameter, T_w = thickness of the pore wall, T_{bar} = thickness of the barrier layer.

Fig.2.3. Schematic diagram of thermodynamics of the oxide growth.

Fig.2.4. Schematic diagrams of aluminum oxide growth according to equifield strength model.

Fig.2.5. Schematic diagram of two-step anodization process for the synthesis of alumina template. (a) untreated aluminum foil (b) electropolished aluminum foil (c) first anodization generates pre-patterned pores (d) chemical etching to remove the alumina layer (e) second anodization forms well-patterned pores.

Fig.2.6. Shows (a) schematic illustration of an electropolishing cell, and (b) electropolishing experimental set-up.

Fig.2.7. A photograph of the wafer anodizing machine.

- Fig.2.8. The experimental set-up for the anodization chamber.
- Fig.2.9. A potentiostatic curve of the porous oxide growth in 0.3 M oxalic acid.
- Fig.2.10. SEM images of pore structure in PAA template at different second anodization time (a) 30 min; (b) 60 min; and (d) 180 min.
- Fig.2.11. The variation of the PAA height as a function of the second anodization time.
- Fig.2.12. SEM images of pore structure in PAA template at different pore widening time (a) 30 min; (b) 60 min; and (d) 75 min.
- Fig.2.13. The variation of the pore diameter as a function of pore widening time, for template anodized in 0.3M oxalic acid at 40V.
- Fig.2.14. A photograph of the experimental set-up for the optical properties measurement system.
- Fig.2.15. Schematic of the experimental set-up for the optical properties measurement system.
- Fig.2.16. Reflection spectra of blank PAA membranes with different thicknesses at an angle of incidence of 30° .
- Fig.2.17. Reflection spectra of blank PAA membranes with different power widening time at an angle of incidence of 30° .
- Fig.2.18. The variation of the effective refractive index of PAA template as a function of the pore diameter.
-

- Fig.3.1. SEM images of pore structure in PAA template after barrier layer (BL) thinning process: (a) top view; (b) cross-sectional view.

Fig.3.2. SEM images of pore structure in PAA template at different cathodic polarization time and 70 min pore widening time: (a) 5 min; (b) 7.5 min; (c) 10 min; (d) 12.5 min.

Fig.3.3. The variation of the pore diameter as a function of the cathodic polarization time at 70 min pore widening.

Fig.3.4. SEM images of pore structure in PAA templates at 10 min cathodic polarization and different pore widening time: (a) 20 min; (b) 40 min; (c) 60 min; (d) 70 min.

Fig.3.5. The variation of the pore diameter as a function of the pore widening time after 10 min cathodic polarization compared with the case of ordinary pore widening.

Fig.3.6. The top view SEM images of PAA membranes ordinary pore widened for (a) 80 min; (b) 90 min.

Fig.4.1. Schematic diagram of the process used to obtain Au nanorods/PAA composite and free standing Au nanorods array supported on Al substrate.

Fig.4.2. SEM images of (a) PAA membranes after the deposition of Au into the pores, (b) the corresponding freestanding Au nanorod arrays after the template has been removed and (c) an oblique angle image to show the height uniformity of the rods.

Fig.4.3. Reflection spectra of Au/PAA composites with various aspect ratios at the incident angle of 30° .

Fig.4.4. The dependence of resonance wavelengths on the AR of nanorods.

Fig.4.5. VIS/NIR reflection spectra of Au nanorod/PAA composite with an aspect ratio of 5.5 for various incident angles.

Fig.4.6. Reflection spectra of freestanding Au nanorod arrays with different aspect ratios at an angle of incidence of 30° .

Fig.4.7. The dependence of resonance wavelengths on the AR of nanorods.

Fig.5.1. Schematic diagram is used to illustrate the four layer structure of the sample.

Fig.5.2. (a) Top view SEM image and (b) oblique view AFM image of head face of blank PAA membrane anodized for 5 min and pores widened for 70 min after 10 min cathodic polarization; AFM images of PAA membranes after sputter-coating with gold for (c) 60, (d) 120 sec; (e) oblique angle and (f) cross-sectional view SEM. The enlarged part shows the attached Au nanoparticles on the sidewall of PAA pores.

Fig.5.3. The variation of (a) the pore diameter, (b) gold nanoparticle diameter, and (c) gold nanoparticle height as a function of the sputtering time.

Fig.5.4. Reflection spectra of PAA membranes coated for various lengths of time, for p-polarized light at an angle of incidence of 45° . The black solid curve is for blank PAA membrane anodized for 5 min and pores widened for 70 min after 10 min cathodic polarization.

Fig.5.5. A schematic diagram is used to illustrate the surface plasmon resonances generated from the interface of Au nanoparticles and PAA.

Fig.5.6. Calculated reflection spectra for p-polarized light at 45° by using the structural parameters that obtained from SEM and AFM images of PAA membranes coated for various lengths of time.

Fig.5.7. The dependence of (a) minimum wavelength, and (b) minimum reflectivity % on the sputtering time.

Fig.5.8. SEM images of PAA membranes at a constant cathodic polarization time of 10 min and at different pore widening times of (a) 40, (b) 50, (c) 60, and (d) 70 min. These PAA membranes were anodized for 5 min and sputter-coated with gold for 20 s; and (e) shows the variation in pore diameter as a function of pore widening time with 10 min cathodic.

Fig.5.9. Diffuse reflectance spectra obtained from PAA membranes at different pore widening times and sputtered for 20 s, for p-polarized light at an angle of incidence of 45° .

Fig.5.10. Calculated reflection spectra for p-polarized light at 45° by using the structural parameters that obtained from SEM and AFM images of PAA membranes at different pore widening times and sputtered for 20 s.

Fig.5.11. The dependence of (a) minimum wavelength, (b) band width, and (c) the oscillation amplitude on the pore widening time.

Fig.5.12. Reflectance spectra measured for various angles of incidence for 40 s- Au-coated PAA membrane anodized in oxalic acid for 5 min, where time of pore widening after 10 min cathodic polarization is 70 min.

Fig.5.13. (a) The dependence of minimum wavelength, and (b) the minimum reflectivity on the angle of incidence.

Fig. 5.14. A photograph of the coated Au-PAA membranes anodized for 5min: (a) pore widened for 70 min and Au-coated for (1) 40 s, (2) 60 s, (3) 80 s and (4) 120 s; (b) Au-coated for 20 s and widened for (5) 40 min, (6) 50 min, (7) 60 min, and (8) 70 min. To relate the saturation of colors observed by eye to the reflection spectra, we indicate to the wavelengths of the maximum reflectivity in each trace of figure 4 and figure 7 by arrows directed to the colored bar.

LIST OF TABLES

Table 1.1. (Propagating) Surface Plasmon & Localized Surface Plasmon

Table 2.1. Summary of previous reports about anodizing conditions and the resulting structural parameters for self –organized PAA membranes.

Table 2.2. Comparison of pore diameter and interpore distance with different electrolytes.

Table 5.1. Sputtering parameters of Au nanoparticles on/in PAA template by r.f. magnetron sputtering

PUBLICATIONS

- *Mohamed Shaban, Hany Hamdy, Fayez Shahin, Joonmo Park, and Sang-Wan Ryu* , " Uniform and Reproducible Barrier Layer Removal of Porous Anodic Alumina Membrane", *J. Nanosci. Nanotechnol.* 10, 3380-3384 (2010).
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ABSTRACT

The self-ordering of porous anodic alumina (PAA) membranes of different pore diameters and thicknesses were investigated. Scanning electron microscopy (SEM) images revealed that the pore diameter and the PAA thickness depend on the pore widening time and the second anodization time, respectively. According to the measured reflection spectra, PAA membrane exhibits a bright color in the visible light range due to the interference of light. The color is bright but its saturation is very low. In addition, the effective refractive indices of PAA membranes were calculated.

A method for the fabrication of PAA membrane without bottom barrier layer on Al substrate is described. In this method, two-step anodizing followed by a barrier thinning process at the end of the second anodization was used to prepare wide range highly-ordered PAA membrane with a thin barrier layer. Finally, cathodic polarization and pore widening processes were combined to remove the barrier layer completely between the oxide film and Al substrate. From the SEM images, the PAA membrane prepared with the assistance of cathodic polarization showed more homogeneous pore diameters and pore wall quality than that made by pore widening only. In addition, the barrier layer was removed completely with 7.5 min of cathodic polarization and 70 min of pore widening without corrosion in the Al substrate. It was possible to control the pore diameter without any damage to the PAA template from 70 to 90 nm. The

fabricated PAA template can be applied to the growth of ordered nanowires, nanorods, nanoparticles, nanotubes, and similar nanostructures.

High-density, uniform-sized and vertically aligned gold nanorods were grown on aluminum substrate by DC electrodeposition into PAA membrane without bottom barrier layer. Optical reflection measurements using s- and p-polarized light showed strong surface plasmon resonances (SPRs), for both Au/PAA composites and freestanding Au nanorods arrays. By changing the aspect ratio of the Au nanorods, the angle of incidence of the polarized light, and the dielectric environment, it was possible to vary the position and the intensity of the SPR reflection minima in a reproducible and predictable manner. We successfully measured higher order transverse SPR, which proves the formation of highly uniform Au nanorods.

We directly develop a facile method to decorate modified porous anodic alumina membrane (PAA) with ultrathin porous film of gold nanoparticles with sub-gaps less than 25 nm and particle size less than 40 nm on the top surface and Au nanoparticles uniformly attached to the pore walls as well as the bottom of the pores, utilizing r.f. magnetron sputtering. The size as well as the interparticle distance of the gold nanostructures is adjusted by changing the structural properties of PAA membrane and the sputtering time. According to the measured reflection spectra, the saturation of interference color is significantly enhanced and as a result, the Au-coated PAA membrane exhibits a brilliant and tunable color. Field enhancement can be achieved in these structures through the excitation and constructive interference of surface

plasmon waves. In addition, the role of localized surface plasmon (LSP) and propagating surface plasmon (PSP) was discussed. Four-layered model is presented to describe the reflectance data that show agreement with the experimental data. The brilliant Au-coated PAA membranes is useful for decorative purposes and holds promise as an effective SERS-substrate.