Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 184 (2017) 637 – 642

Procedia Engineering

www.elsevier.com/locate/procedia

Advances in Material & Processing Technologies Conference

Investigation on the Growth Process of Gold Nanoplates Formed by Seed Mediated Growth Method

Marlia Morsin[a,b]*, Muhamad Mat Salleh[c], Mohd Zainizan Sahdana[a,b], Farhanahani Mahmud[a,b]

[a]*Microelectronics & Nanotechnology - Shamsuddin Research Centre (MiNT-SRC), Institute of Integrated Engineering (I2E), Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat Johor, Malaysia*
[b]*Faculty of Electronic and Electrical Engineering (FKEE), Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat Johor, Malaysia*
[c]*Institute of Microengineering and Nanoelectronics (IMEN), Universiti Kebangsaan Malaysia, 43600 National University of Malaysia (UKM), Bangi, Selangor, Malaysia*

Abstract

Gold nanostructures have unique surface plasmon resonance (SPR) properties and it is widely used in photolectronic and sensing applications. In this study, gold nanostructures focusing on gold nanoplates have been fabricated on the quartz substrate using seed mediated growth method (SMGM). The SMGM consists of two processes which are seeding process and growth process. The effect of growth time during growth process on the formation of gold nanoplates on substrate surface was studied. The growth time was varied from 30 minutes to 18 hours to observe its density and optical properties on the substrate surface. The XRD analysis shows two peaks occurs at the plane (111) in position ~ 38.2º and plane (200) at ~ 44.3º. Through variation of the growth time, the optimum surface density is 93.5 % with a total of 59.4 % of the nanoplates shape from 5 hours growth time sample. The optical absorption spectrum of the sample shows two resonance peaks, ~ 558 nm and 675 nm, which are corresponding to the transverse surface plasmon resonance (t-SPR) and the longitudinal surface plasmon resonance (l-SPR) respectively. Hence, it is found that the growth time affected the formation of the gold nanostructures. Longer growth period caused an increase in the formation of gold nanorods instead of gold nanoplates.

Peer review under responsibility of the organizing committee of the Advances in Materials & Processing Technologies Conference

Keywords: Localized Surface Plasmon Resonance; Gold Nanoparticles; Growth Time; Plasmonic Sensor; Seed Mediated Growth Method (SMGM)

* Corresponding author. Tel.: +6074538612 ; Fax: +6074536060.
E-mail address: marlia@uthm.edu.my

Peer review under responsibility of the organizing committee of the Advances in Materials & Processing Technologies Conference
doi:10.1016/j.proeng.2017.04.130

1. Introduction

The unique characteristics of gold nanostructures have attracted researchers due to its potential applications in sensing, catalysis, thermal, photoelectronic devices and other related fields. Numerous researches have been done in synthesizing different gold nanostructures such as spherical, rods, hexapods, cubes, ribbons and hollow nanocages [1-4]. These two parameters; shape and size greatly affects the optical and electronic properties of gold nanostructures. The high homogeneity in size and shape are very suitable to be used in plasmonic sensors.

There are two approaches in fabricating gold nanostructures; physical and chemical approach. The physical approach such as lithography requires high cost equipment and long preparation time. Besides, the substrate size is limited to the determined standard size [5]. The chemical approach is simpler but needs thoroughness to control chemical reactions [6]. One of the wet chemical synthesis approach namely Seed Mediated Growth Method (SMGM) is able to produce anisotropic nanoparticles in high yield with varying size, shape and structure [7]. Furthermore, this method can be carried out in room temperature with simple preparation and low cost compared to physicals method.

In this study, gold nanostructures focusing on gold nanoplates have been fabricated on the quartz substrate using Seed Mediated Growth Method (SMGM). The SMGM consists of two processes which are seeding process and growth process. The effect of growth time during growth process on the formation of gold nanoplates on substrate surface has been studied. The growth time varied from 30 minutes to 18 hours to observe its density and optical properties on the substrate surface. The high density and homogeneity of gold nanoplates have been sought to obtain sharp, intense and narrow absorbance peak of the optical spectrum.

2. Experimental Method

In this experiment, Seed Mediated Growth Method (SMGM) has been used to synthesize gold nanoplates on quartz substrate. The process consists of two stages; seeding process and growth process. The seeding process started with impose positive charge on the substrate surface by dipping 5% seed enhancer namely poly-l-lysine (PLL) for 30 minutes. Then, the positive surface quartz substrate was immersed into seed solution for two hours. The seed solution was prepared by mixing 0.5 ml of 0.01 M hydrogen tetrachloroaurate, $HAuCl_4$ (Sigma Aldrich, USA) with 2.0 ml of 0.01 M trisodium citrate, $C_6H_5Na_3O_7$ (Wako Pure Chemical Ltd, Japan) and 18 ml deionized (DI) water. After that, 0.5 ml of 0.1 M cold aqua sodium tetraborohydride, $NaBH_4$ (Sigma Aldrich, USA) was added into the solution. The substrate was immersed into seed solution for 2 hours at room temperature. In order to strengthen the gold nanoseeds on the surface, the substrate was annealed at 150 ºC for 1 hour using a vacuum oven. After seeding process, the substrate was immersed into the growth solution for 30 minutes to 18 hours. The growth solution was prepared by mixing 0.5 ml of 0.01 M $HAuCl_4$, 10 ml of 1 mM poly (vinyl pyrrolidone), PVP (Sigma Aldrich, USA), 8 ml of 0.1M cethyltrimethy ammonium bromide, CTAB (Sigma Aldrich, USA) and 2 ml DI water with the addition of 0.1 ml of 0.1 M ascorbic acid (Wako Pure Chemical Ltd, Japan). Finally, the substrate was annealed at 100 ºC for 1 hour to remove the surfactant residue on the substrate. All the solutions of these chemicals were prepared using DI water with resistivity around 18.2 MΩcm from pure lab UHQ ELGA.

3. Results and Discussions

The samples are fabricated using Seed Mediated Growth Method through two stages; seeding process and growth process. The growth process contains of two main steps; immerse samples in growth solution and annealing process. In this study, growth time (the period during immersion process of substrate in growth solution) was varied from 30 minutes until 18 hours to observe the growth of nanoplates on the substrate surface. To facilitate discussion, the samples are labelled as GT0.5 (30 minutes), GT1 (1 hour), GT5 (5 hours), GT8 (8 hours), GT10 (10 hours) and GT18 (18 hours).