Janus Micro Gold Shells Fabricated by Wireless Electrochemistry

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ABSTRACT

This work reports a new method to partially coat a film of our interest on a microbead with a thin gold shell, briefly 'gold ball', using wireless electrochemistry. The key point of this method is to control the potential of the external electrodes, which will drive an electrochemical reaction on the gold ball in a microchannel without any electric contact. This method allows partial modification of a variety of organic or inorganic compounds that can electrochemical reaction.

KEYWORDS: surface modification, Janus particle, wireless electrochemistry, gold ball

INTRODUCTION

Janus particles have been interested in many applications, such as a dual-functionalized sensor or barcode. And bicolored Janus particles with a electrical anisotropy can change colors in a electric field so that it is expected to be potential candidate for electric paper or display materials.

Typical method for making janus particles is toposelective method, such as using partially masked particle, microcontactprinting, reactive directional fluxes or fields, particle on a hydrophillic and hydrophobic solution interface [1]. Other methods are polimerization synthesis and optofluidic synthesis. But previous synthesis of Janus particles is not simple and modification materials have a some limitation.

THEORY

Recently wireless electrochemistry attracts keen attention because it requires no electric contact and thereby very useful to induce electrochemical reactions on a conductor in the middle of a microchannel. Bradley *et al.* reported that they demonstrated electrodeposition of Pd on one side of a graphite particle and on CNT in a bulk electrochemical cell by bipolar electrochemistry [2, 3]. Warakulwit *et al.* electroplated gold on one side of CNT in a capillary electrophoresis [4]. In spite of pioneering works on this method, no heterogeneous electrodeposition on gold ball by wireless electrochemistry in a microfluidic chip has been reported. In this work, we showed partial modification of a half of the gold ball surface by wireless electrochemical method on a microfluidic channel.

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EXPERIMENTAL

The site-specific electrodeposition on the gold balls was demonstrated by the experiments as follow. First, gold balls were suspended in an aqueous solution containing 0.2 M acetate buffer (pH 3.6), 0.1 M $NaNO_3$ and 0.1 M pyrrole. And then the suspension was injected into a microfluidic channel. The gold wires were placed in the reservoir and applied an electric potential difference between the two electrodes as delineated in Figure 1.

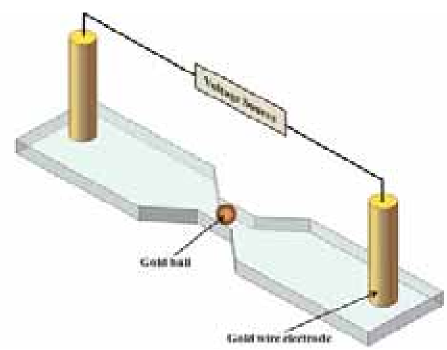

Figure 1. Schematics of microchip based by wireless electrochemistry with Janus gold ball

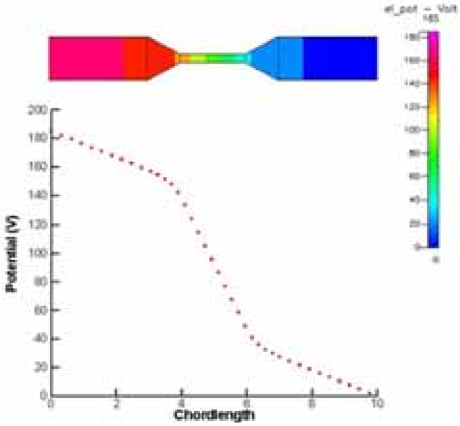

Figure 2. Potential gradient on microchannel obtained by computation result

RESULTS AND DISCUSSION

The electric potential profile along the microchannel can be calculated as shown in Figure 2. Large potential difference is applied at the middle of narrow channel. So both ends of gold ball are affected by significnat potential difference although relatively low potential is applied on two gold electrodes.

Because microchannel has larger resistance than electric double layer of gold electrode, almost potential is applied on microchannel. So, we can electropolymerize polypyrrole on half side of a gold ball in a microchannel.

In this case, the potential difference that the gold surface feels was estimated as shown in Figure 3.

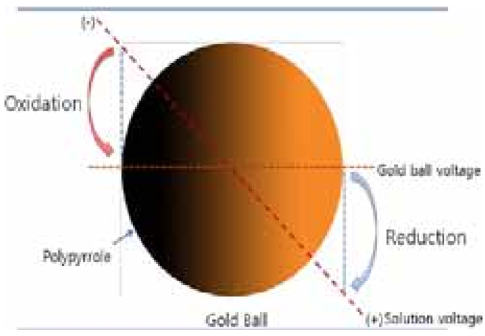

Figure 3. Illustration of redox reaction on gold ball in wireless electrochemistry
Left side of gold ball surface is high potential than left side of solution. So electrons transfer solution to gold ball surface. (Oxidation of pyrrole)
Right side of gold ball surface is low potential than right side of solution. So electrons transfer gold ball surface to solution. (Reduction)

We confirmed that electropolymerization of polypyrrole occurred on one side of a gold ball when 0.8 V was applied, observing that one side of the gold ball turned black due to the polypyrrole as displayed in Figure 4.

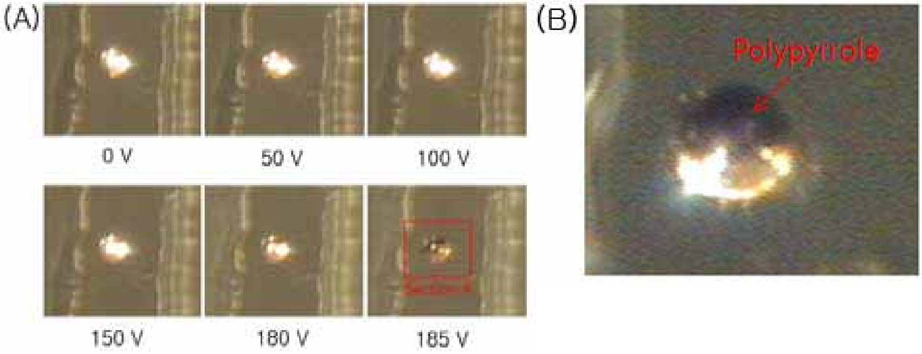

Figure 4. (A) Electrodeposition of polypyrrole on a gold ball(dia. 20μm) under various voltage. (magnification : X 600) (B) Enlargement of section A (magnification : X 1200)

CONCLUSIONS

The Janus gold balls were produced by wireless electrochemical technique and are expected to allow partial modification of a variety of metals or functional molecules including fluorescent dyes, enzymes, proteins or DNA on either side of the micro gold beads.

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