Fabrication of Au lamellae nanostructure for high sensitive biosensor applications

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Since the lamellae nanostructures inside the Morpho butterfly wing scales were exposed by electron microscope in 1960s, attempts for replicating such a unique structure for iridescent structural colors had been widely tried but not succeeded until a recent breakthrough in the technical development for dielectric lamellae layers,[1] using a one-step electron beam lithography combined with alternating development/dissolution. This success enables us to directly reveal the essence of iridescent blue/green and offers us a great opportunity for further extending the dielectric lamellae structures to gold ones, as schematically illustrated in figure 1. In principle, metallic photonic crystal nanostructures with multilayers own excellent and fascinating properties and has demonstrated a wealth of physical properties in surface plasmonic resonance (SPR), surface-enhanced Raman scattering (SERS) and surface-enhanced fluorescence. All these characteristics lead to promising application such as biosensors with high sensitivity.

In this paper, we report the nanofabrication of gold lamellae structures, the so-called “gold butterfly wings” as shown in figure 1, by imaging the lithographically replicated dielectric lamellae layers in resists via Au electroplating (figure 2). The fabricated gold lamellae layers are presented in figure 3. The developed process is also applicable to other metals such as Ag, Ni and Cu. FDTD simulations have been carried out to explore the electromagnetic field distribution under a collimated source plane wave with TE or TM polarization. The reflectivity and electric field distribution are show in figure 4. Local surface plasmonic resonance can be observed in both the reflection and the calculated electric field distribution. Also, the reflectivity and SERS result are being characterized in our lab. It is anticipated that such a 3D metallic structure exhibits sensing function with high sensitivity as a biosensor.

By summary, we have developed a novel process based on alternated development/dissolution and electroplating to explore the sensing capability of gold Morpho butterfly wing scales as SPR and SERS. The process developed in this work is of application prospects in multidisciplinary areas.

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[1] S. Zhang and Y. Chen, *Sci. Rep.* **5** (2015).

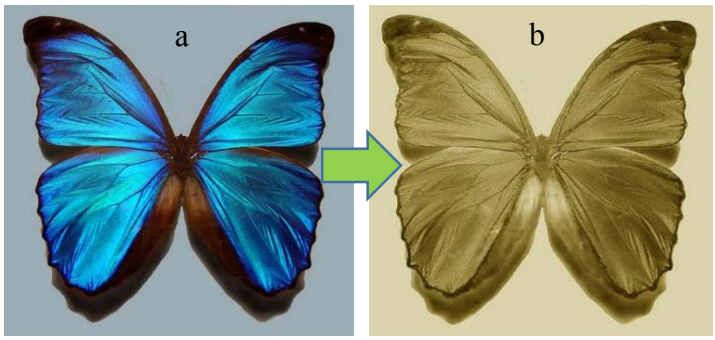

Figure 1: Illustration showing the conceptual conversion of natural Morphs butterfly wing is converted into gold wings. (a) The real morphos butterfly. (b) The electroplated butterfly with Au.

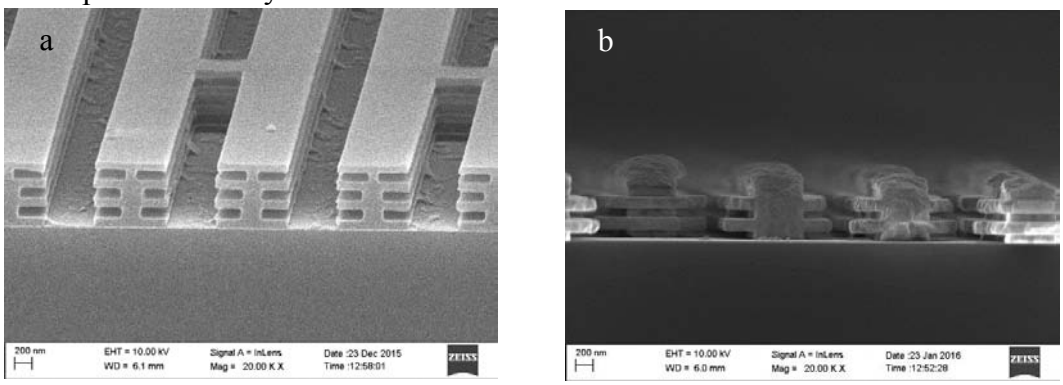

Figure 2: The SEM images of the fabricated lamellae structures. (a) The dielectric lamellae layers in resists. (b) The gold lamellae structures.

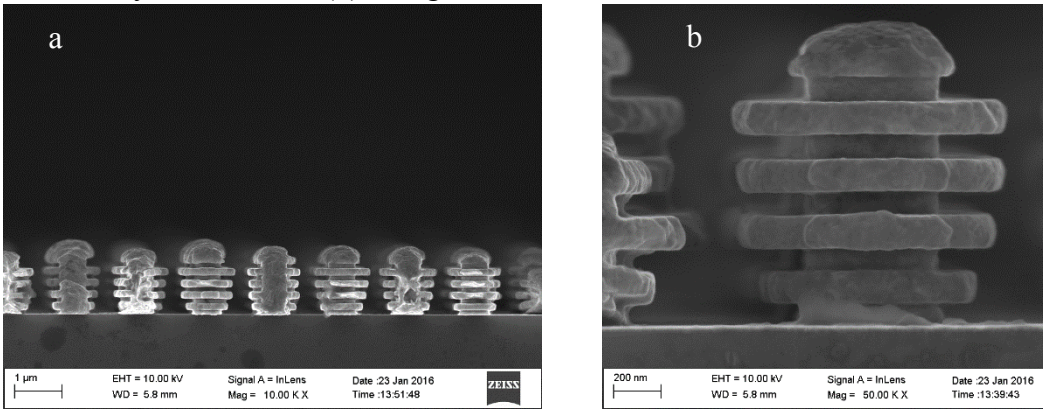

Figure 3: The SEM images of gold lamellae structures with more layers in different magnification. (a) 10 K magnification. (b) 50 K magnification.

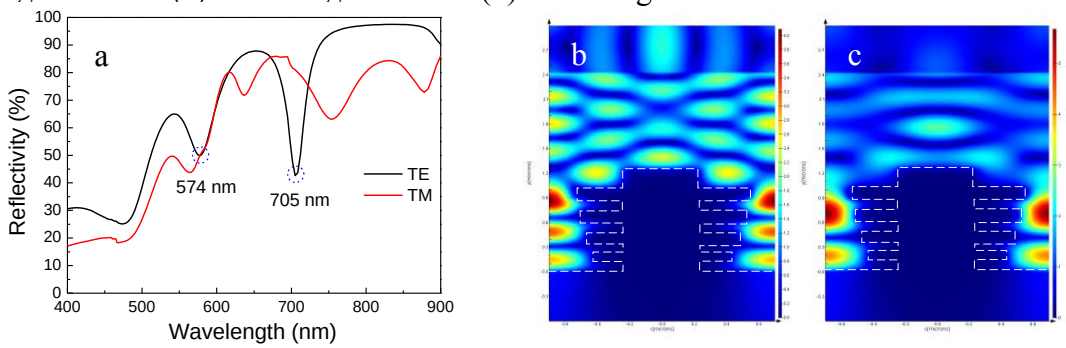

Figure 4: The simulated results of gold lamellae structures by FDTD. (a) Reflectivity. (b) Electric field distribution under TE polarization at 574 nm and (c) 705 nm.