課題番号 :F-16-HK-0071

利用形態 :共同研究

利用課題名（日本語） :

Program Title (English) :Interplay of hot electrons from localized and propagating plasmons

利用者名（日本語） :

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## 1. 概要（Summary）

Plasmon-induced hot-electron generation has recently received extensive attentions and has been applied to optoelectronics, photovoltaics and water splitting. Such hot electrons are typically generated from either localized surface plasmons resonances (LSPRs) in metal nanoparticles (NPs) or surface propagating polaritons (SPPs) in patterned metal nanostructures. Here, a simultaneous generation of the plasmon-induced hot electrons via LSPRs and SPPs was studied. And we further exploited their cooperative interplay in a single metal-semiconductor device.

## 2. 実験（Experimental）

【利用した主な装置】

原子層堆積装置(Picosun SUN ALE-R), ヘリコンスパッタリング装置 (ULVAC MPS-4000C1/HC1)

【実験方法】

A 200 nm Au layer was deposited onto the FTO substrate. Subsequently, a 20 nm $TiO_2$ layer was deposited. Then, an ultra-thin Au layer was deposited. For embedding the AuNPs in $TiO_2$, a 5 nm $TiO_2$ top layer was deposited under the same condition as the deposition of the 20 nm $TiO_2$ layer. The device was annealed at 450℃ in a dried air environment to produce AuNPs in the $TiO_2$ layer. The functionality of the device was investigated by the photoelectrochemical measurement technique in a three-electrode system: Pt as counter electrode, Ag/AgCl as reference electrode, and the dual-plasmon device as a working electrode

## 3. 結果と考察（Results and Discussion）

As schematically shown in Figure 1a, the plasmonic device is composed of a 25 nm-thick $TiO_2$ active layer in which AuNPs (~4 nm in diameter) are embedded at a distance of 5 nm below the top of $TiO_2$ layer, and a 200 nm Au film was observed below the $TiO_2$ layer. The plasmon device produces a polarized net photocurrent that determined by the balance in population and directionality between the hot electrons from LSPRs and SPPs, as showed in Figure 1b. The current responsivity and polarity switching wavelength of the device can be tuned over the whole visible region via manipulating the hot-electron interplays. This unique phenomenon may provide flexibility to manipulate light-matter interaction and offer fascinating opportunities for the application of biosensors, long-distance communications, and photoconversion applications.

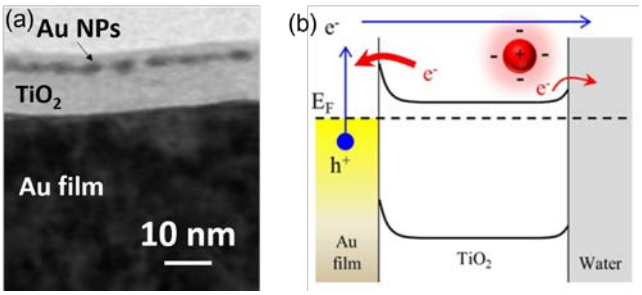


Figure. 1 (a) Cross-sectional TEM image of Au-NPs/$TiO_2$/Au film structure. (b) Working principle of the device under the optical excitation of the LSPR of the AuNPs.

## 4. その他・特記事項（Others）

共同研究者: X. Shi, Q. Sun, K. Ueno, H. Misawa

## 5. 論文・学会発表（Publication/Presentation）

Viet V. Tran, Oanh T. T. Nguyen, Chi H. Le, Tuan A. Phan, Ban V. Hoang, Thang D. Dao, Tadaaki Nagao and Chung V. Hoang, “Sub-10 nm, high density titania nanoforests–gold nanoparticles composite for efficient sunlight-driven photocatalysis”, Jpn. J. Appl. Phys. 56, 095001 (2017)

## 6. 関連特許（Patent）

なし。