Plasmon-enhanced hot electron emission at thin-TiO_2/Au junction

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Introduction

Titanium dioxide (TiO_2) has been widely investigated in a recent decade due to its various applications in biocompatible materials, gas sensors, photocatalysis, photovoltaics, etc. We studied the hot electron emission at a Schottky barrier consisting of a thin (a few nm) TiO_2 film and Au. Since the TiO_2 is thin enough to excite surface plasmons (SPP) at the TiO_2/Au interface with simple Kretschmann geometry, the hot electron generation is concentrated at the interface, enhancing the internal quantum efficiency (IQE) by ~30 times from that without SPP particularly for lower photon energies.

Experiment and result

Figure 1 shows our typical device configuration: BK7 / Ti(2 nm) / Au(50 nm) / TiO_2(*t* nm) / air.

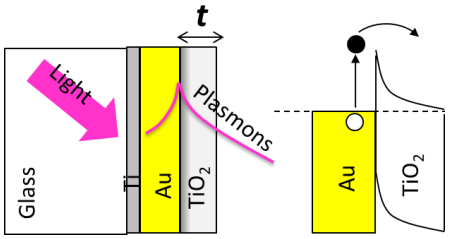

Fig. 1. Schematics of the device of interest and band diagram for hot electrons emission.

We simulated IQE for the case of (a) t = 5 nm in Fig. 2, where light is from BK7, the barrier height is 1 eV, and no bias is applied [1]. The enhancement by SPP reaches ~30 times around 1.2 eV compared to the case that (c) normal incident light is from the air side, which does not support SPP. The field intensity and thus IQE decrease as the TiO_2 thickness increases (Fig. 2, curve (b)). We experimentally prepared Au (40 nm) and Ti (5 nm) films deposited on a BK7 substrate by k-cell and e-beam evaporations, respectively. Ar/O_2 (20:80) plasma was subsequently applied to oxidize its Ti. Ellipsometry and I/V characterization revealed that ~3 nm TiO_x was formed and the barrier height was confirmed to be 0.7-1.2 eV. Interestingly, TiO_x in this sample has larger grain sizes than that formed from thick Ti (80 nm) by the same oxidation process (Fig. 3). Optimization of the fabrication and characterization will be addressed.

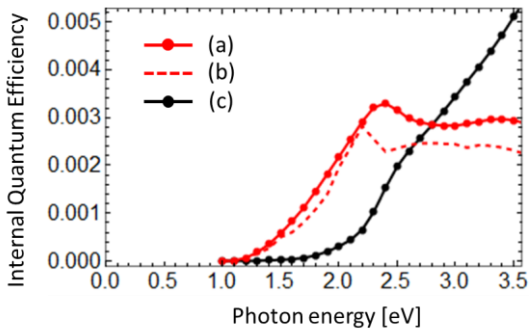

Fig. 2. Calculated internal quantum efficiency. (a): BK7/Ti(2nm)/Au(50nm)/TiO_2(5nm)/air. Light is from the BK7 side. (b): (a) of 20-nm TiO_2. (c): Normal incident from the air side of (a).

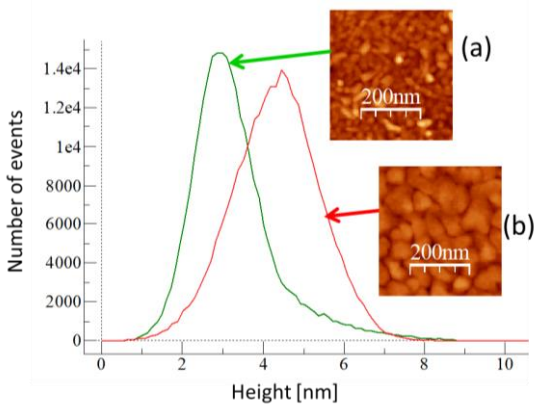

Fig. 3. Histogram of the grain heights of plasma-oxidized (a): Ti(80nm) and (b):Ti(5nm)/Au(40nm) on BK7 substrates.

Reference

[1] A. J. Leenheer *et al.*, J. Appl. Phys. **115**(13), 134301 (2014).