High Temperature Photovoltaic Effect at Nb Doped $SrTiO_3$/Electrode

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Introduction

Electronic properties at the interface between electrode and $SrTiO_3$ (STO) are important in various advanced devices such as VLSI [1], DRAM [2] etc. As is well known, Schottky barrier exists at the interface between an electrode and a semiconductor. Many studies have been made on the barrier formation at the metal/STO interfaces [3-5]. So far, however, very few attempts have been made to study its high temperature characteristics.
Recently, the authors found that a finely prepared interface on a donor doped STO single crystal shows a clear rectification effect even at elevated temperatures up to 873K[6].

In this study, we investigated the photovoltaic effect of Nb doped STO/electrode interface in various P_{O2} at high temperatures in order to confirm existence of Schottky barrier at high temperatures.

Experimental

Single crystal disks, 16mm in diameter and 0.5mm in thickness, of nominal 0.01 wt% Nb doped $SrTiO_3$ (STNO) (100) were supplied by Nakazumi Crystal Laboratory. Surfaces of the disks were polished to an optical level. As the working electrode (WE), ITO (In_2O_3:SnO_2 = 95:5 wt%) was deposited on STNO by a Pulsed Laser Deposition technique (PLD). As the counter electrode, Pt was deposited for the current collector. La-heavily doped $SrTiO_3$ ($La_{0.1}Sr_{0.9}TiO_3$: LSTO) layer was deposited between Pt and STNO to attain ohmic contact. For PLD, substrate temperature was kept at 873K. The chamber was filled with O_2 of approximately 1 bar for oxide electrode deposition, and evacuated to approximately 10^{-4} bar for metal electrodes. Schematics of electrodes on the sample are shown in Fig. 1. I-V characteristics were measured using a potentiostat/FRA instrument (ECOCHEMIE Co., PGSTAT30). Ultraviolet (UV) light was irradiated to the interface from the ITO side. An UV spot light source (USHIO Inc, SPOT-CURE® SP-7) with band pass filter (365 nm) was used.

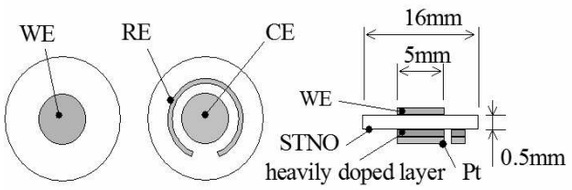

Fig. 1 Schematic view of the sample.

Results ant Discussion

Current-voltage (I-V) characteristics of ITO/STNO interface at high temperatures are shown in Fig. 2. The interface showed rectification effect that is caused by Schottky barrier. The rectification effect depended on P_{O2}. This is consistent with our previous results for the other electrode materials; i.e. the barrier formation mechanism essentially follows Bardeen model [7].
I-V characteristics of ITO/STNO interface that was irradiated by UV light is shown in Fig. 3. The interface showed photovoltaic effect even at high temperatures. It is a strong evidence of existence of Schottky barrier at the interface even at high temperatures.

In Fig. 3, intercepts of x-axis and y-axis correspond to open circuit voltage (OCV) and short circuit current (SCC), respectively. OCV and SCC are unexpectedly high, approximately 200 mV and 2 mA cm^{-2}, respectively at 673K. From Fig. 3 OCV increases and SCC decreases with the increase in P_{O2}. This is consistent with the observed P_{O2} dependence of the rectification effect.

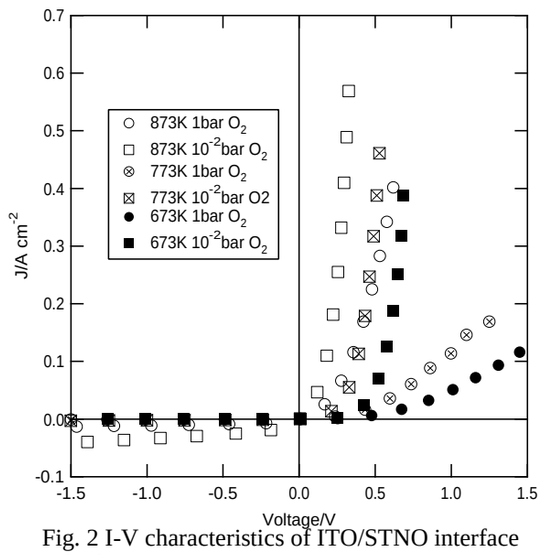

Fig. 2 I-V characteristics of ITO/STNO interface at high temperatures.

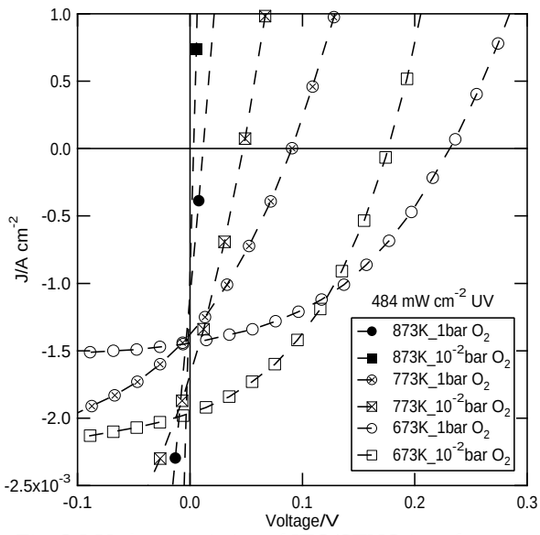

Fig. 3 I-V characteristics of ITO/STNO interface at high temperatures under 484 mW cm^{-2} UV.

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