Formation of pn junction using α-MnTe/AZO stack structure for new photovoltaic and electronic applications

Tohoku Univ.[1], ○ (M1)Mihyeon Kim[1] , Shunsuke Mori[1], Daisuke Ando[1], Yuji Sutou[1]
E-mail: kim.mi.hyeon.q2@dc.tohoku.ac.jp

The pn junction forms the basis of semiconductor technology and it is one of the simplest semiconductor devices that has been used for many kinds of applications; solar cells to convert light energy to electronic power and selector devices to access memory cells. It is well known that most pn diode devices are composed of Si, however, as Silicon devices pushed to their limits, the development of new semiconductor-compound materials are expected for next generation. We focus on a chalcogenide material, namely Manganese Telluride. Recently, it has been reported that it has proper energy band gap for light absorber layer of solar cells. [1] MnTe showing p-type semiconductor is expected to be applied for various pn-junction semiconductor devices. Here, we focus on Al-doped Zinc Oxide, called AZO, as n-type semiconductor. AZO is well known for its non-toxicity, and low-production cost. The formation of pn junction between AZO and α-MnTe can be expected from following 3 features; their semiconductor types, structural similarity, and suitable energy band gaps for use as solar cells.

α-MnTe/AZO stack structures were deposited on the thermal-SiO_2(725μm)/Si(100nm) substrate with by RF magnetron sputtering. Tungsten as a backside contact was deposited. And MnTe was deposited on the contact with 10nm of SiO_2 as an oxidation barrier layer. To obtain a high crystallinity of α-MnTe, the sample was annealed at 500˚C. After annealing, SiO_2 layer was removed by reverse sputtering. And then, AZO was deposited just above α-MnTe layer. Front contact was formed by photolithography. The optical transmittance of AZO and α-MnTe in the wavelength range between 300nm and 10μm were measured at room temperature. As a result, the energy band gap of α-MnTe and AZO were estimated to be 1.37eV and 3.32eV respectively by Tauc Plot. The band diagram of the stack structure was investigated by estimating fermi energy of α-MnTe by hall measurement at temeperature range of 200-400K. The suggested diagram indicated that they can form a pn heterojunction. Also, carrier density, N_d of each layer was investigated. Consequently, pn diode characteristics were obtained in the stack structure. And AZO(330nm, N_d: $6.51 \times 10^{13}\mathrm{cm}^{-3}$)/α-MnTe(500nm, N_d: $5.56 \times 10^{20}\mathrm{cm}^{-3}$) showed the diode function with the ideality factor of 6.62, as shown in Fig. 1.

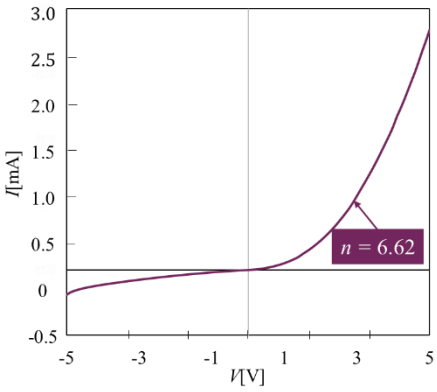

Fig1. *I-V* characteristics on AZO/α-MnTe stack structure

[1] S. Mori et al, Optical and Electrical Properties of α-MnTe Thin Films Deposited Using RF Magnetron Sputtering, Materials Transactions, Vol. 59, No. 9, pp. 1506-1512 (2018).