Reduction the optical losses in CdTe/ZnTe thin-film solar cells

S. Chusnutdinow[1], R. Pietruszka[1], W. Zaleszczyk[1], V.P. Makhniy[2], T. Wojtowicz[1] and G. Karczewski[1]

[1] *Institute of Physics, PAS, Al. Lotników 32/46, 02-668 Warsaw, Poland*
[2] *Yuri Fedkovych Chernivtsi National University, 2 Kotsyubynsky Str., 58012 Chernivtsi, Ukraine.*

Optical losses affect the effectiveness of power conversion of solar cells by lowering the short-circuit current. The optical losses depend on transmission and reflection of solar cell materials. In the case of CdTe/ZnTe solar cells the reflectance of the structures exceeds 20%. The high reflectance is due to high refractive indexes of CdTe and ZnTe: at 840 nm they are 2.97 and 2.83, respectively. We report on reduction of the optical losses by surface texturing and formation of anti-reflection coating (ARC) on the top of CdTe/ZnTe thin-film solar cells grown by molecular beam epitaxy (MBE). The thin-film heterojunctions were grown on monocrystalline, semiinsolating (100) GaAs substrates from elemental sources. The n-type CdTe films were doped by iodine. The p-type ZnTe layers were nitrogen-plasma doped.

Surface texturing of the ZnTe top window was done by electrochemical etching in HNO_3:HCl:H_2O (1:4:20) acid solution by employing of a two electrodes method. After electrochemical etching we observe a strongly corrugated surface structure with etch pits of submicron size (Fig. 1a). As anti-reflection coatings and transparent contacts undoped and Al-doped ZnO thin-films were deposited. The Al-doped ZnO is highly conductive and its refractive index equals to 1.95 at 840 nm, i.e., it is significantly reduced in comparison to ZnTe or CdTe. Both ZnO films were deposited by Atomic Layer Deposition on the top surface of the solar cells. The thickness of the antireflection films was in the range of 80-110 nm. In a wide spectral region the transparency of the antireflection films exceeds 90%. By employing the antireflection coatings the reflectance of CdTe/ZnTe solar cells reduces from 20% to 2% at 840 nm. Basic parameters of illuminated solar cells, the open-circuit voltage, V_{OC}, and the short-circuit current, I_{SC}, can be determined from the expression: $I_{SC} = I_{SC}^{0} \exp(eV_{OC}/nkT)$. Due to reduction the optical losses we observe that I_{SC} increases by almost 70% (Fig. 1b) and the efficiency by 44 % from 4.5 to 6.5%. The V_{OC} does not change.

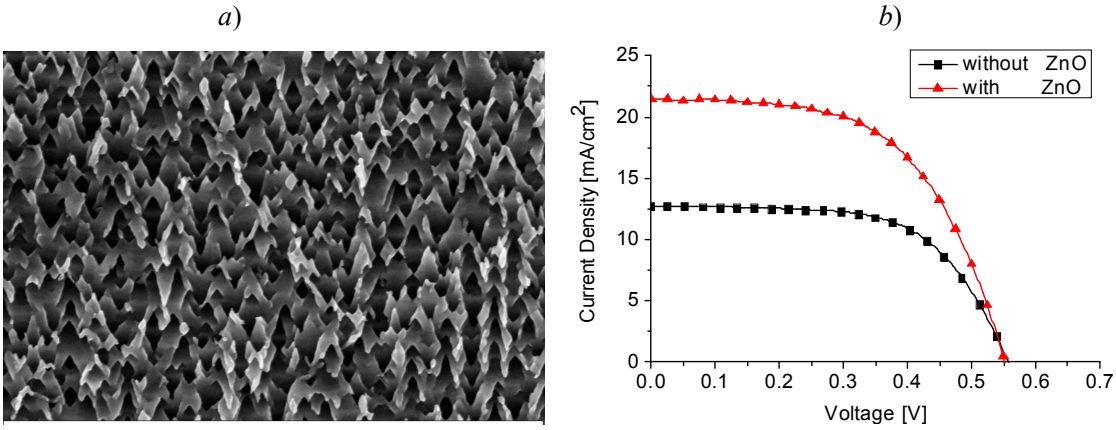

Figure 1: a) SEM image textured surface of ZnTe, b) Illuminated current–voltage characteristics for n-CdTe/p-ZnTe heterojunctions with and without ARC.

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