Photovoltaic properties of AZO/Cu_2O heterojunction devices using AZO films deposited by magnetron sputtering

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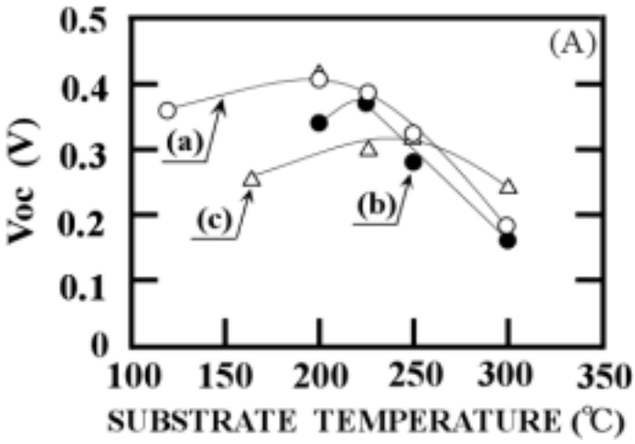
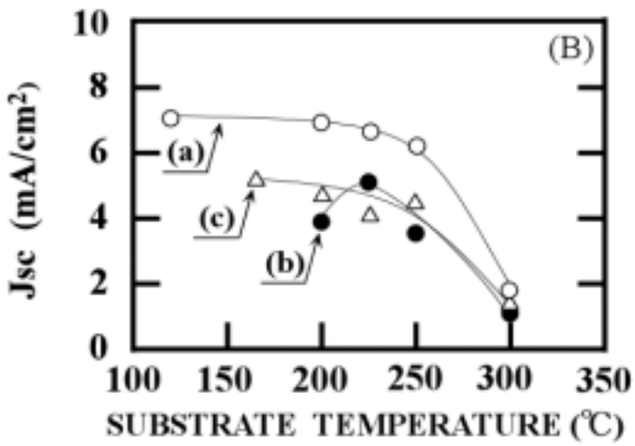
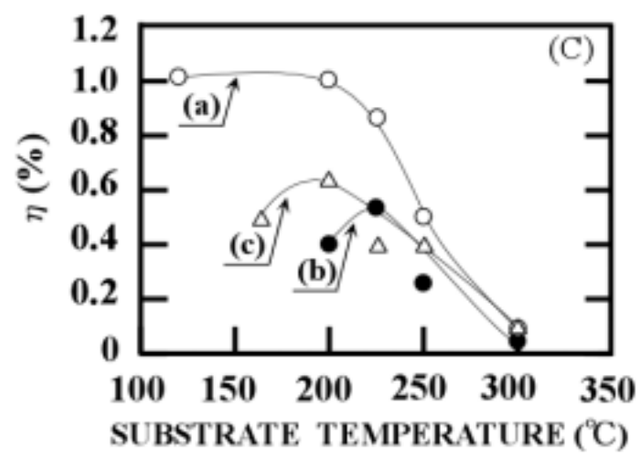
Although various Cu_2O heterojunction solar cells have been reported up to now, there are no reports of any exhibiting an energy conversion efficiency over 1%. This paper describes the relationship between the deposition conditions and the photovoltaic properties of newly developed AZO/Cu_2O heterojunction devices fabricated on a Cu_2O sheet with a transparent conducting AZO film. N-type semiconducting AZO thin films were deposited by either d.c. magnetron sputtering or r.f. magnetron sputtering on Cu_2O sheet substrates that were placed in various positions relative to the target. One Cu_2O substrate was set perpendicular to the target surface (a), and two were set parallel to the target surface (b and c); the positions of (b) and (c) corresponded to locations opposite the center and the erosion area of the target, respectively. The p-type semiconducting Cu_2O sheets (thickness of approximately 0.2 mm), prepared by a heat treatment of copper sheets, functioned as the active layer as well as the substrate in the photovoltaic devices. An Au thin film was deposited on the back side of the Cu_2O substrate as an ohmic electrode. All fabricated AZO/Cu_2O heterojunction devices exhibited a rectifying characteristic, irrespective of the AZO thin film deposition conditions or the substrate placement during deposition. As an example, Fig. 1 shows (A) open-circuit voltage (V_{OC}), (B) short-circuit current density (J_{SC}), and (C) conversion efficiency (η) as functions of the substrate temperature for AZO/Cu_2O heterojunction solar cells fabricated with AZO films deposited at three deposition positions by r.f. magnetron sputtering. The obtained photovoltaic properties of the devices fabricated at temperatures above approximately 250°C worsened because the resistivity of the Cu_2O sheets increased as a result of the heat. It should be noted that the obtained photovoltaic properties of the devices fabricated with the (a) substrate arrangement were better than those of the devices fabricated with either the (b) or (c) arrangement. The variation in the photovoltaic properties relative to the substrate arrangement may be explained by the resulting interface layer and the extent of damage introduced on the Cu_2O surface during the AZO deposition. Using AM2 solar illumination, a high efficiency above 1% was obtained in devices fabricated with AZO thin films deposited by r.f. magnetron sputtering at temperatures up to about 200°C on substrates oriented perpendicular to the target.



(A) Substrate temperature dependence of an open circuit voltage (V_{OP})



(B) Substrate temperature dependence of a short circuit current density (J_{SC})



(C) Substrate temperature dependence of a energy conversion efficiency (η)

Fig. 1 Photovoltaic properties as functions of substrate temperature for AZO/Cu_2O devices under AM2 solar illumination