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PHOTOELECTROCHEMICAL CELL with CUPROUS OXIDE ELECTRODE

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Abstract

Cuprous oxide films, a few μm thick, were galvanostatically deposited on stainless steel substrates. From the dependence of conductivity on temperature the conductivity activation energy was calculated. Upon illumination the photoconductivity was observed. Power characteristics of a photoelectrochemical cell Cu_2O/electrolyte/Pt were measured from which a conversion efficiency was estimated.

1. Introduction

Cuprous oxide is a potentially useful semiconductor material for photovoltaic solar energy conversion. Cu_2O has not received a great deal of attention since modern purification and crystal growing techniques have been developed. On the basis of the large amount of work carried out on Cu_2O[1] it could be regarded as a "defect" semiconductor, excess oxygen leading to p-type conduction with two activation energies, $E_1/2$ (1.82-2.6 eV) and E_2 (0.3-0.5 eV). Recently, several techniques have been used to prepare thin Cu_2O films as solar selective layers[2-4].

The preparation method of this highly available material is described in this paper. Some of its conductive properties are measured and the photoelectrochemical investigations are done.

2. Preparation of specimens

Thin Cu_2O films are cathodically deposited on stainless steel substrates[3] from the solution composed of anhydrous cupric sulphate, lactic acid and sodium hydroxide (concentrations: 0,4, 2,7 and 4 mol dm^{-3}, respectively) kept at temperature $60 \pm 0,1^{\circ}C$. The parameters during galvanostatic deposition are 0,8 mA cm^{-2}, t=3900 s (specimen a , thickness 5,1 μm) and 0,7 mA cm^{-2}, t=4800 s (specimen b , thickness 4 μm).

Deposition parameters (current density and voltage) are controlled and measured simultaneously by using a Nucleus Instruments galvanostat Model ECP 130. Film thickness is estimated from the conditions during deposition. X-ray diffraction showed that all films were polycrystalline.

3. Results and discussion

Fig. 1. shows the temperature dependence of conductance in the range from 193 K to 423 K. The surface conductivity is estimated and is of the order of 10^6 Ω / □ . Semiconductor properties of electrodeposited films could be seen from Fig. 1. The conductivity acti-

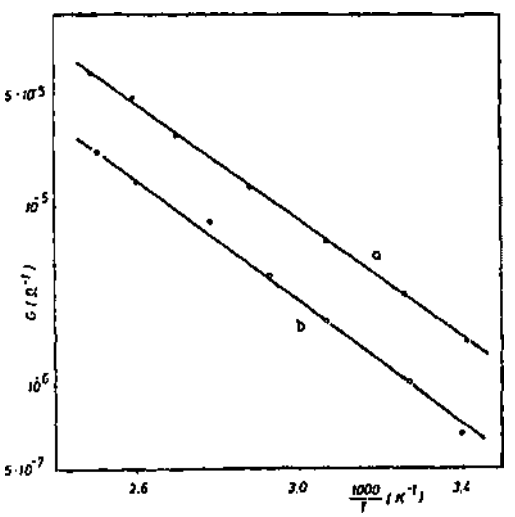
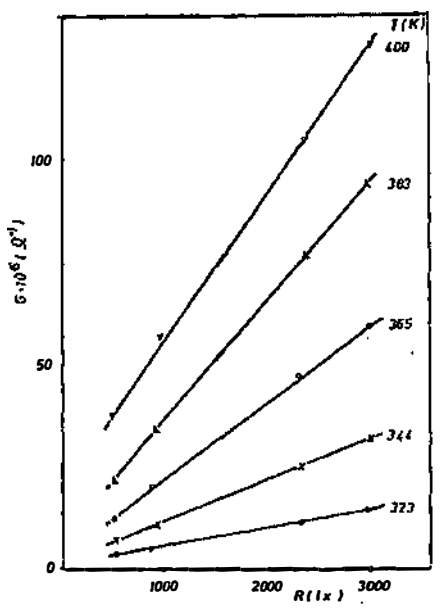


Fig. 1. The dependence of Cu_2O conductance on temperature for two different specimens. The specimen b is thinner than a. The resistivity is of the order of 100 Ω cm .

vation energy is 0.4 eV in accordance with the experimental results for specimens obtained by similar techniques[1,4]. From Fig. 2. it is obvious that films are photosensitive, opening the posibility for Cu_2O application in a photoelectrochemical cell as a photoactive electrode.

While some reports about the photovoltaic Cu_2O cell performance could be found in literature[4] there are no data about photoelectrochemical cells with cuprous oxide electrode as far as we know. Therefore a photoelectrochemical behaviour of thin cuprous oxide photoelectrodes is also investigated and briefly discussed in this paper.

Fig. 3. shows the power characteristics of the cell Cu_2O/electrolyte/Pt, illuminated with white light source, an 800 W Osram lamp. Cu_2O film is a photocathode in this experiment indicating p-type conductivity



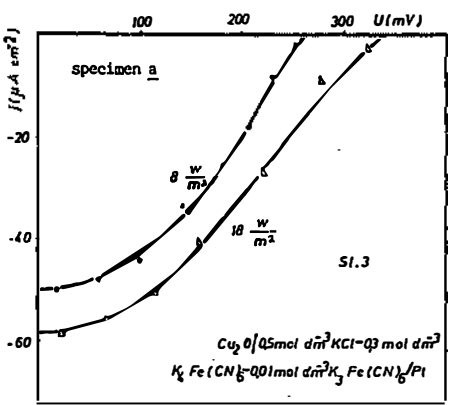


Fig. 3. Power characteristics of the Cu_2O/electrolyte/Pt cell

Fig. 2. The dependence of Cu_2O conductance on illuminance at different temperatures (specimen a).

of cuprous oxide specimens. Open circuit voltage U_{oc} is 400 mV at low light intensities. Economou et al.[4] obtained only 20 mV with photovoltaic Cu_2O cells. As a consequence of high resistivity of cuprous oxide films short current densities are very low, of the order of 10 $\mu A\ cm^{-2}$, leading to a conversion efficiency of only 0.1%. This numerical result is in accordance with most literature data for polycrystalline photoelectrodes[5]. Fill factor is estimated to be between 0.3 and 0.4.

The main problem is a high surface resistivity of the electrodeposited cuprous oxide films. Because of the attractiveness of the producing method further work is planned to lower the resistivity and increase lifetime of Cu_2O photoelectrodes in photoelectrochemical cells.

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