Electrical properties of the p-$CuNiO_2$/n-Si heterojunction produced by radio frequency magnetron sputtering

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Introduction

$CuNiO_2$ belongs to a group of materials called delafossites, which are known for their wide range of electrical properties. The conductivity of these materials can vary from insulating to metallic. $CuNiO_2$ as other delafossites have good photocatalytic properties and could possibly be used for reduce water in a solar water-splitting device [1].

Experimental technique

Thin $CuNiO_2$ films (~ 150 nm thick) were obtained by RF magnetron sputtering on glass substrates and on plane-parallel *n*-Si plates. A stoichiometric mixture of CuO and NiO was used to make the target. Substrate temperature $t°_S$ = 350 °C, spraying was carried out with spraying time t = 30 min and magnetron power P = 180 W. Its resistivity was ρ = 20 Ω·cm.

Experimental results and their discussion

The dependence of the transmittance for $CuNiO_2$ thin films applied by high-frequency magnetron sputtering on the wavelength range λ = 0.5-1.1 μm takes the value of T ~ 40 %. In the region of wavelengths λ < 0.4 μm, a sharp decrease in the transmission coefficient is observed due to the intrinsic absorption edge of $CuNiO_2$ films [2]. The method of independent measurement of transmission and reflection coefficients was used to determine the absorption coefficient of $CuNiO_2$ thin films. The light reflection coefficient R in the studied region of the spectrum for films $CuNiO_2$ is R ≈ 20%. For the studied films, the optical width of the band gap was determined by extrapolating the rectilinear sections to the energy axis. The optical width of the band gap is E_g = 2.81 eV and absorption of light photons takes place by means of direct optical transitions [2].

Studies of *I-V*–characteristics of anisotype *p*-$CuNiO_2$/*n*-Si heterostructures at forward and reverse biases in the temperature range T = 295 – 344 K indicate the rectifying properties of the structures (Fig.1). The rectification ratio at |V| = 0.7 V and T = 295 K was RR ~ 10^2. The diode characteristics of the heterostructure are due to the energy barrier $q\varphi_k$ ~ 0.3 eV from the *n*-Si side (Fig.1, inset). At forward biases of 0.04 V < V < 0.1 V in the structure of *p*-$CuNiO_2$/*n*-Si the generation-recombination mechanism of current transfer prevails (Fig.2, inset – curve 1). At V > 0.1 V the tunnel mechanisms of current transfer with participation of surface states (Fig.2, inset – curve 2), with the activation energy E_a ~ 0.13 eV, prevail. The reverse current at biases –0.3 V < V < –3kT/q V is determined by generation mechanism of current transfer. At –2 V < V < –0.3 V the tunnel mechanisms of current transfer, with the activation energy E_a ~ 0.28 eV. The *p*-$CuNiO_2$/*n*-Si heterostructure is photosensitive at reverse displacement under AM1.5 radiation conditions.

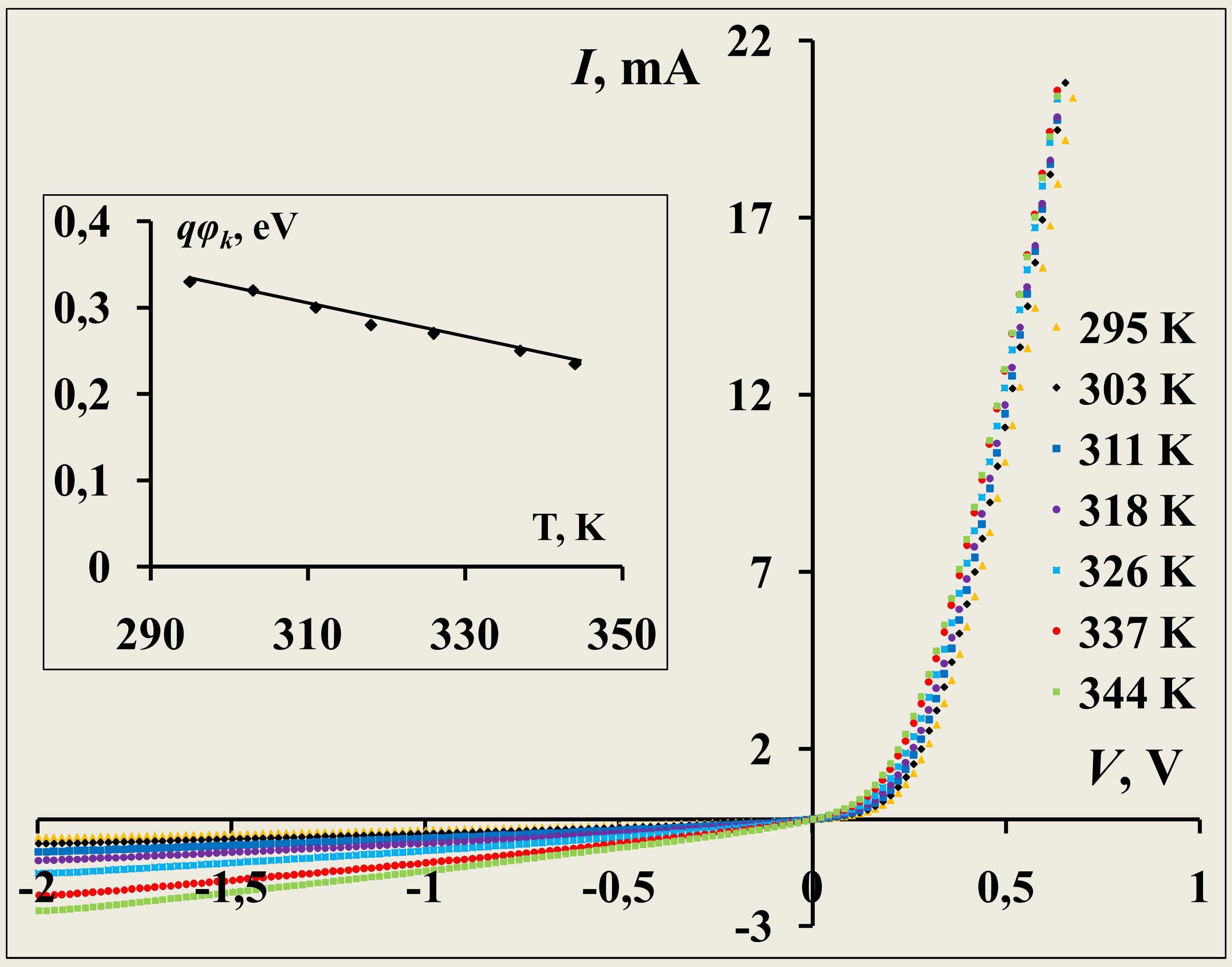

Fig. 1. *I-V*-characteristics of the *p*-$CuNiO_2$/*n*-Si heterostructure in the temperature range from 295 K to 344 K (inset - temperature dependence of $q\varphi_k$)

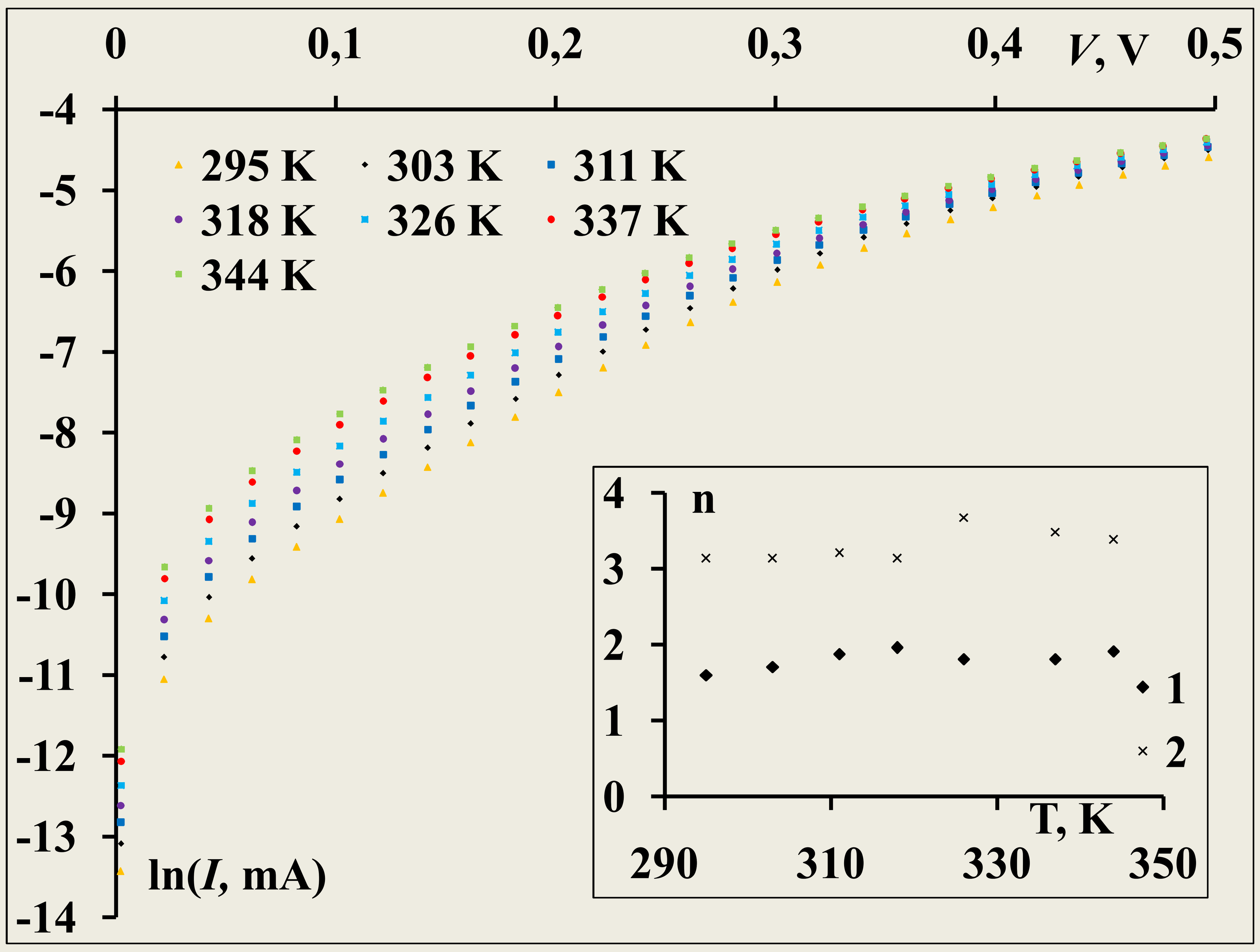

Fig. 2. Dependences ln$I$ = $f(V)$ at forward biases applied to the *p*-$CuNiO_2$/*n*-Si heterostructure at different temperatures (inset – temperature dependence of non ideality factor: 1) 0.04 V < V < 0.1 V; 2) V > 0.1 V)

References

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