Current Transfer Mechanisms in $CuMoO_4$/*n*-Si Heterostructure

Ivan P. Koziarskyi, Eduard V. Maistruk and Dmytro P. Koziarskyi

Yuriy Fedkovych Chernivtsi National University,
Kotsubinsky Str., 2, 58002, Chernivtsi, Ukraine

Delafossite ($CuMoO_4$), together with other minerals of its group, is known for a wide range of electrical properties. Its conductivity can vary from insulating to metallic materials. $CuMoO_4$ nanocomposites can be used for the manufacture of electroluminescent devices as a photocatalyst. This compound also refers to transparent conducting oxides (TCO) – these are semiconductors that combine transparency to visible light and high electrical conductivity in one material. The development of *p*-type TCO will give us opportunities that cannot be used only with *n*-type materials, such as transparent *p-n* heterojunction, diodes, transistors.

Thin films of $CuMoO_4$ (thickness ~ 100 nm) were obtained by RF magnetron sputtering on glass substrates (for optical studies) and on plane-parallel *n*-Si plates (for obtaining heterostructures). A stoichiometric mixture of CuO and MoO_2 was used to manufacture the target. The temperature of the substrate T_S = 613 K, sputtering was carried out for 30 min, with a magnetron power of 180 W.

To determine optical coefficients, a method based on independent measurement of transmission and reflection coefficients was used. For the obtained films, transmission coefficient ~ 30 – 40% in the visible region. The presence of a straight section near the region of the own absorption edge on the dependences $(\alpha h\nu)^2 = f(h\nu)$ confirms the fact that the process of absorption of light photons takes place with the help of direct optical transitions. For the studied films, by extrapolation, the optical band gap E_g^{op} = 4.1 eV was determined.

On the basis of the *I-V*-characteristics obtained at different temperatures (Fig. 1) by extrapolation of linear sections of forward branches, the value of the height of the potential barrier was estimated and its temperature dependence was constructed (Fig. 1, inset), from which the temperature coefficient of change in the height of the potential barrier was determined and its values at 0 K, which are equal to $d(q\varphi_k)/dT$ = -1.9·10^{-3} eV/K and $q\varphi_k$(0 K) = 0.75 eV, respectively.

Fig. 1 shows that the *p*-$CuMoO_4$/*n*-Si heterostructure has rectification properties, the rectification ratio $RR \approx 120$ for $|V|$ = 0.4 V and T = 294 K. According to the slope of the temperature dependence $ln(R_s) = f(10^3/T)$, the activation energy of charge carriers is determined, which is E_a = 0.25 eV.

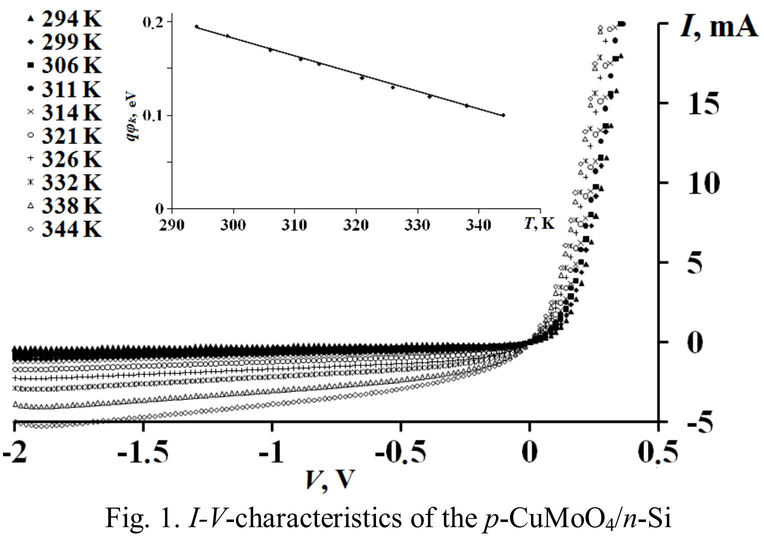

Fig. 1. *I-V*-characteristics of the *p*-$CuMoO_4$/*n*-Si heterostructure at different temperatures (inset: $q\varphi_k = f(T)$)

At forward biases of $3kT/q$ V < V < 0.2 V, the generation-recombination mechanism of current transfer prevails in the *p*-$CuMoO_4$/*n*-Si structure. The reverse current at biases -2 V < V < -$3kT/q$ V is determined by tunneling processes involving surface states.

The *p*-$CuMoO_4$/*n*-Si heterostructure is photosensitive under reverse bias under AM1.5 radiation conditions.