SPECTROSCOPIC PROPERTIES OF NICKEL IONS IN $Zn_{0.9}Cu_{0.1}O$ THIN FILM GROWN USING PLD METHOD

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Abstract

Thin films of zinc oxide (ZnO) doped with copper (Cu) exhibit interesting spectroscopic properties that can find applications in various fields. In photocatalysis, the addition of copper modifies the energy band structure, enhancing the efficiency of photocatalytic processes. This can be beneficial for the removal of organic pollutants or the degradation of toxic substances in water or air. Also, Cu-doped ZnO thin films can be utilized in solar energy, and as gas detectors. Furthermore, Copper doping can influence the magnetic properties of ZnO, opening up possibilities for its utilization in spintronics. Spintronics utilizes electron spins for the transfer, storage, and manipulation of information. ZnO:Cu materials can be employed in the production of spin transistors, tunnel diodes, and other spin-based electronic devices. Electron paramagnetic resonance (EPR) has been used to study and characterize the magnetic, structural and spin properties of materials.

Experiment

Thin layers of copper-doped ZnO were deposited on Al_2O_3, Si (111) substrates in vacuum (vacuum value is missing) by pulsed laser deposition (PLD). The ZnO target was prepared by powder pressing and then sintered. The media were prepared by sequential ethanol cleaning. The layers were obtained with a KGd(WO4)2Nd3+ laser, lambda = 1067 nm, duration ~20 nc, pulse frequency 1-2 Hz. The number of pulses N ~ 500 pulses, with an energy density of 0.5 J / cm2, the typical sedimentation rate was about v ~ 0.5 nm / pulse. The temperature of the ubstrate was set at 200 °C.

Electron magnetic resonance spectroscopy was carried out in temperature range of 90 K to 300 K using the Bruker liquid nitrogen gas-flow cryostat with 41131 VT digital controller, and in the range of 4 K to 300 K using the Oxford Instruments ESR 900 liquid helium gas flow cryostat with Mercury iTC digital controller, by Bruker multifrequency and multiresonance FT-EPR ELEXSYS E580 spectrometer with X-band with the sensitivity of 7 x 10^9 spins/0.1 mT having resolution 2.35 (micro) T or even better.

The measurements of magnetic resonance spectra were performed on X-band (v = 9.4 GHz) with 100 kHz magnetic field modulation Bruker E500 EPR spectrometer.

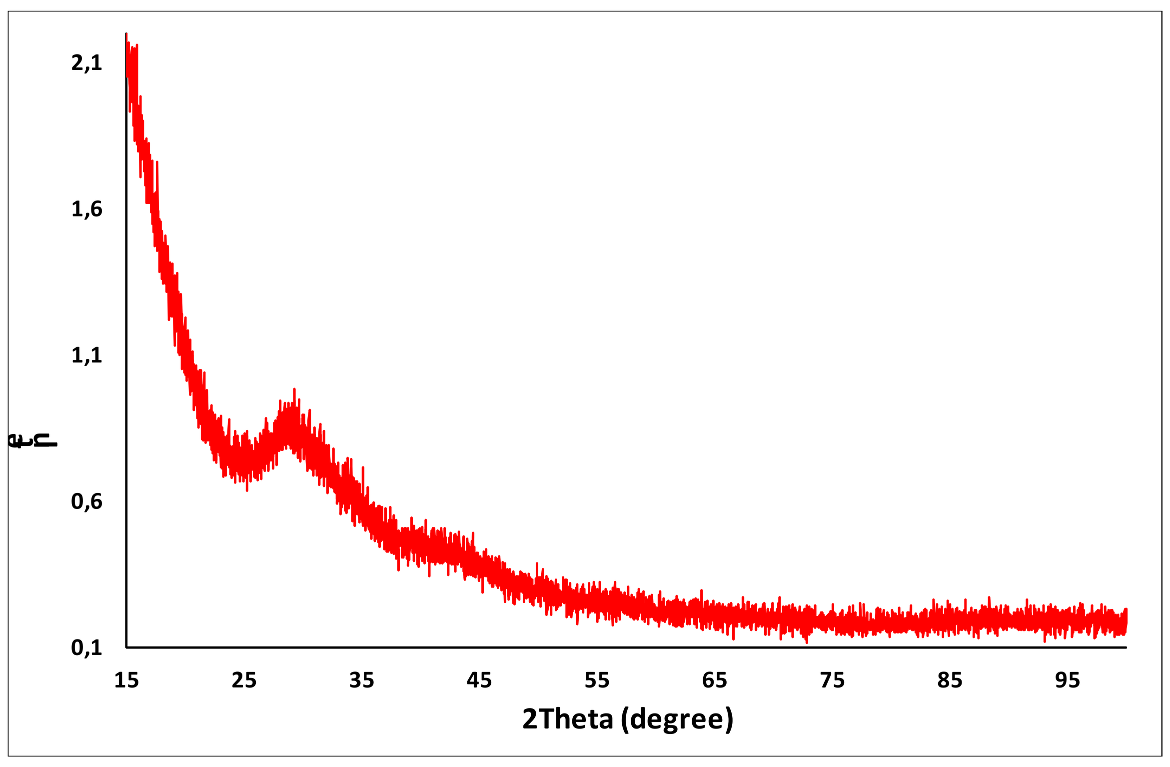

Fig. 1. Graphical representation of the recorded X-ray patterns of ZnO:Cu.

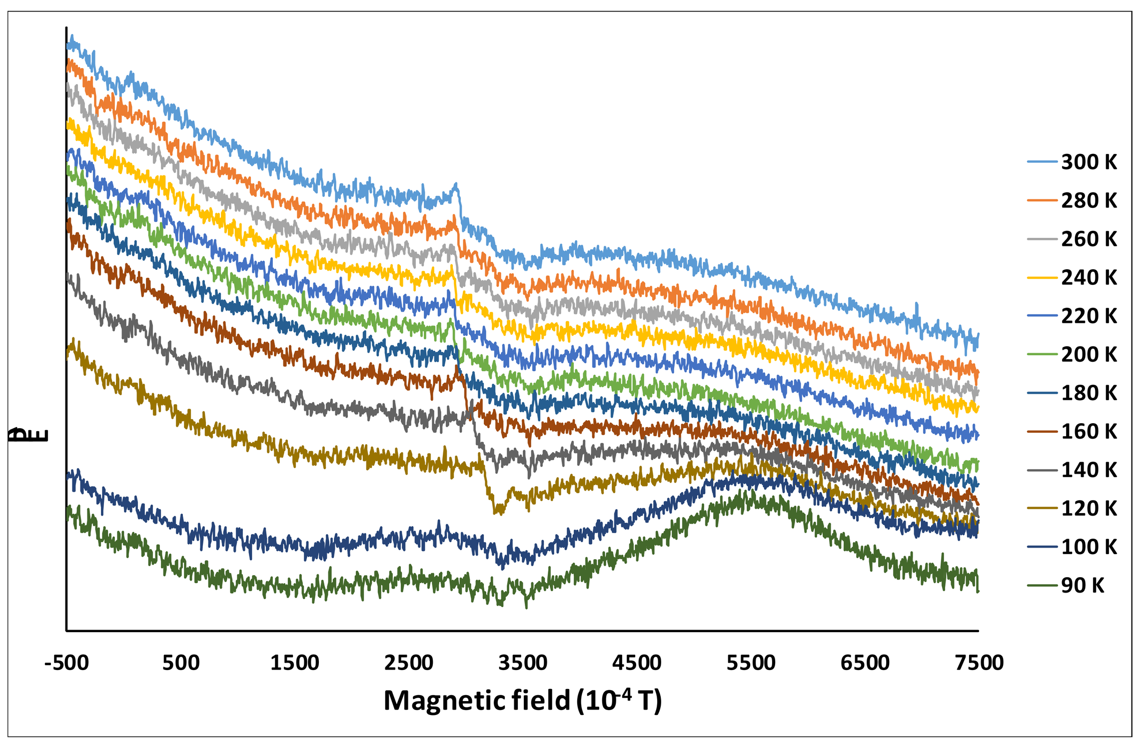

Fig. 2. EPR spectra of the ZnO:Cu sample measured in temperature range from 90 to 300 K.

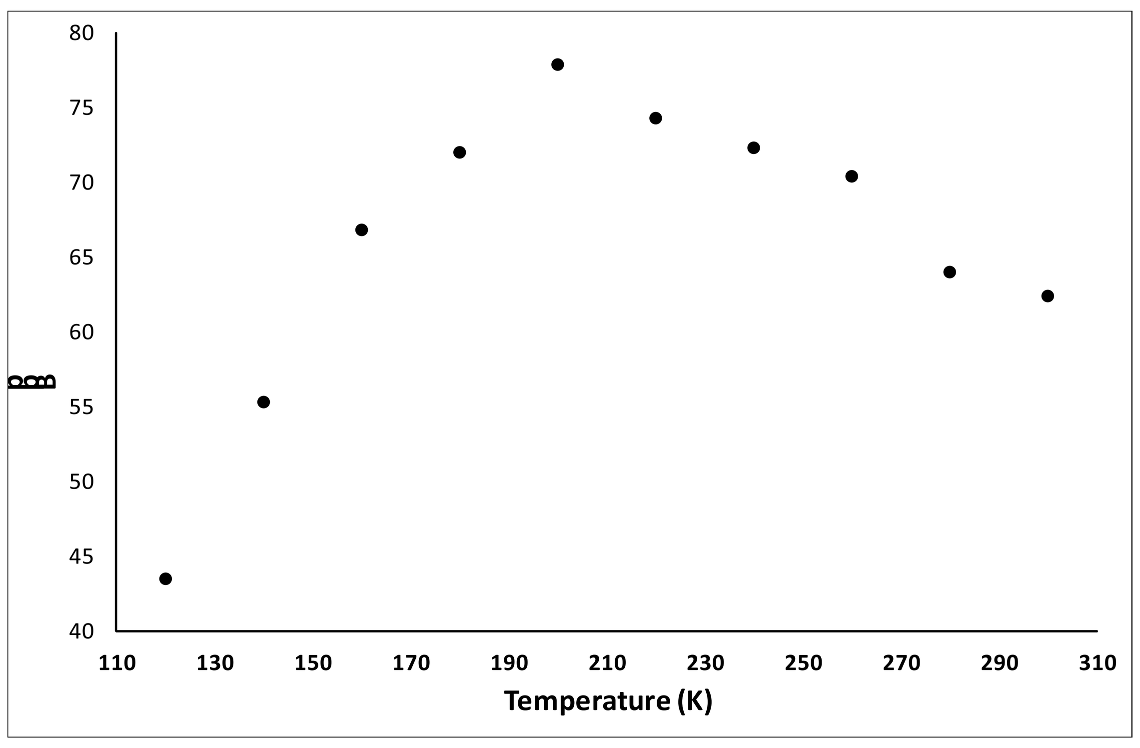

Fig. 3. Peak to peak width (Bpp) dependence of EPR spectra of ZnO:Cu.

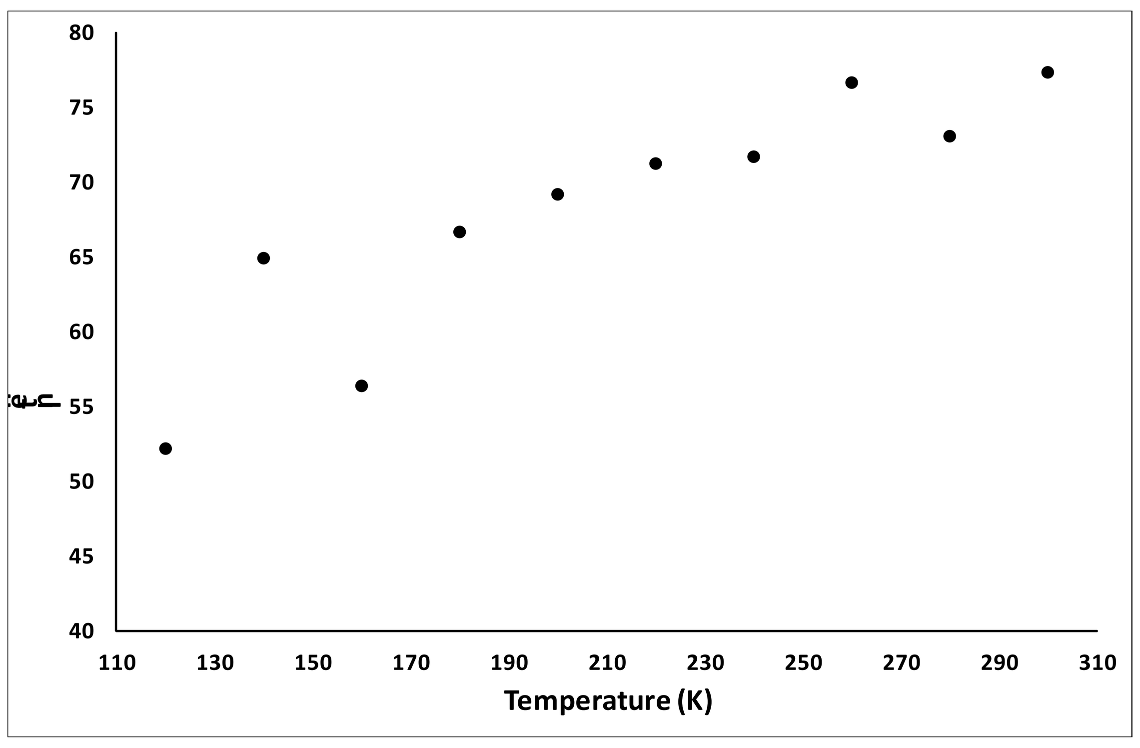

Fig. 4. Intensity (Int.) dependence of EPR spectra of ZnO:Cu.

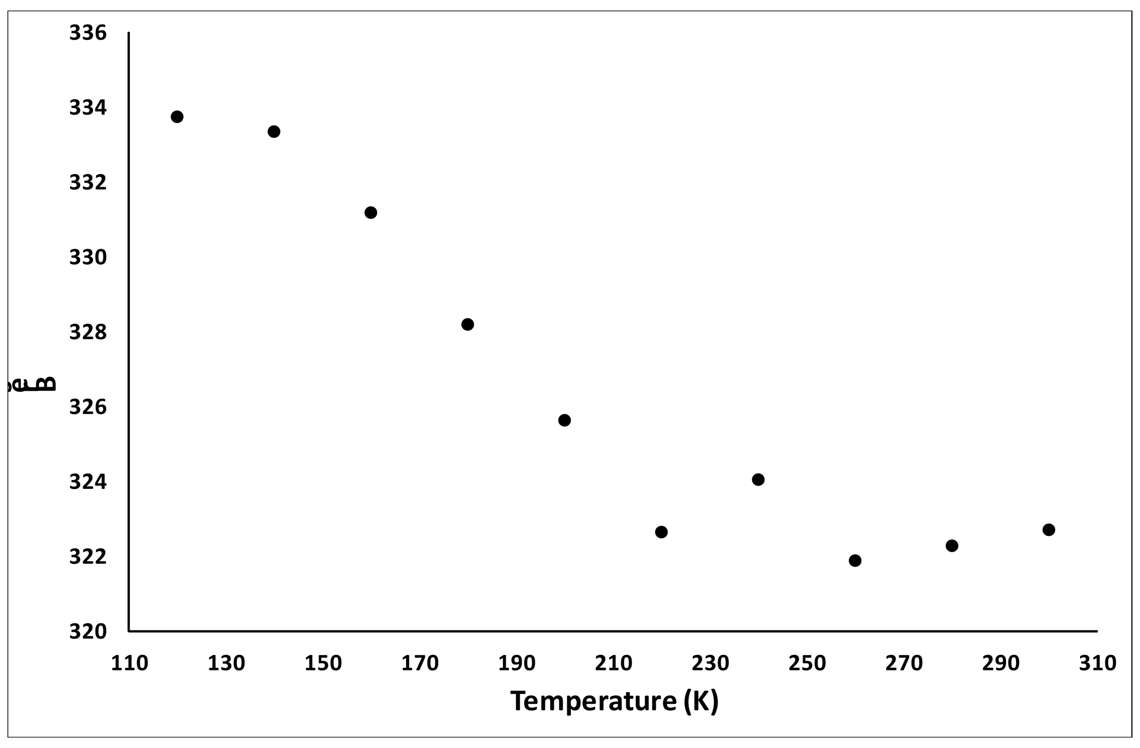

Fig. 5. Resonant field (Bres) dependence of EPR spectra of

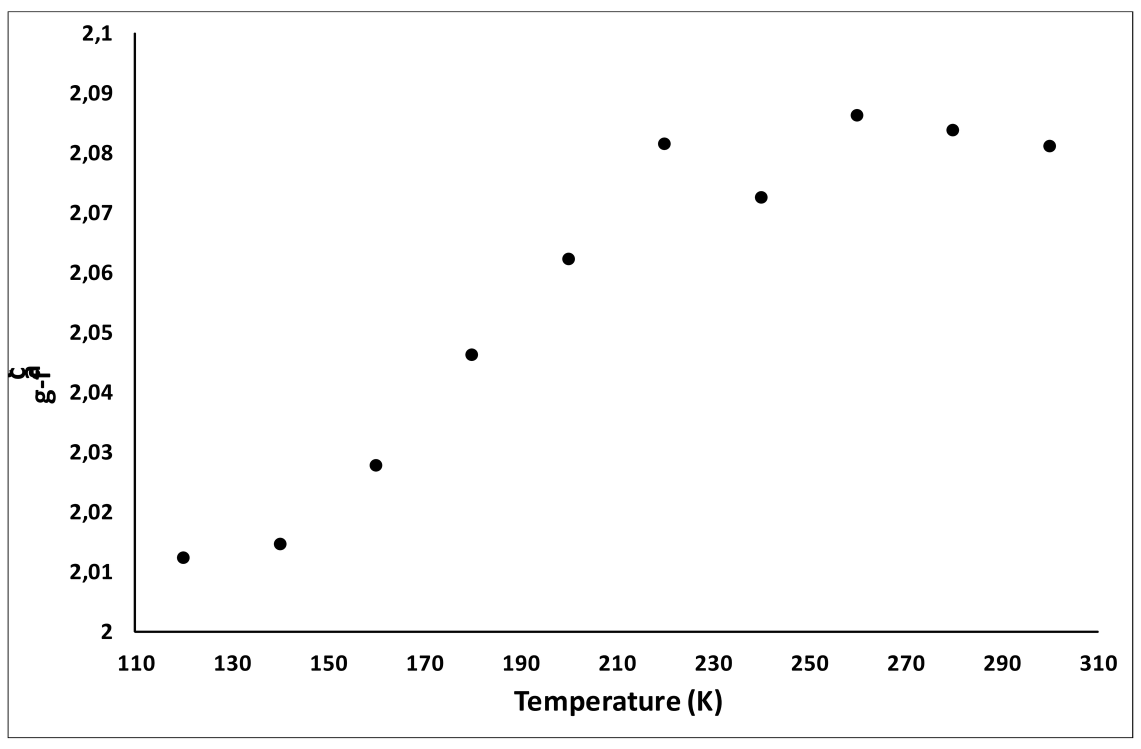

Fig. 6. G-factor dependence of EPR spectra of ZnO:Cu.

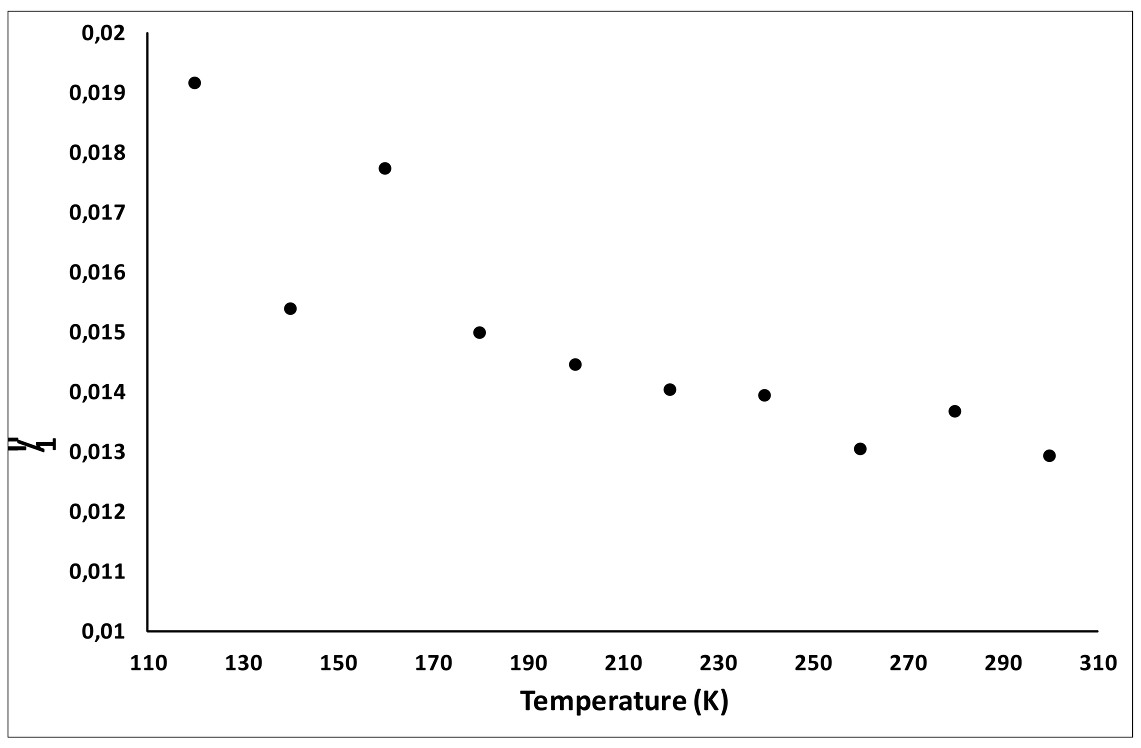

Fig. 7. Inverse intensity dependence of EPR spectra of ZnO:Cu.

We used the Curie-Weiss law to analyze the temperature dependences of the integral intensity, which is directly proportional to the magnetic susceptibility χ. A linear increase of $\chi^{-1}(T)$ at higher temperatures can be fitted to the Curie-Weiss law:
$(\chi-\chi_0)^{-1}(T)=(T-Q_{CW})/C$
where C is the Curie constant, Q_{CW} is the paramagnetic Curie temperature, and χ_0 is a temperature independent term to account for the diamagnetic host and any Pauli paramagnetism contribution.

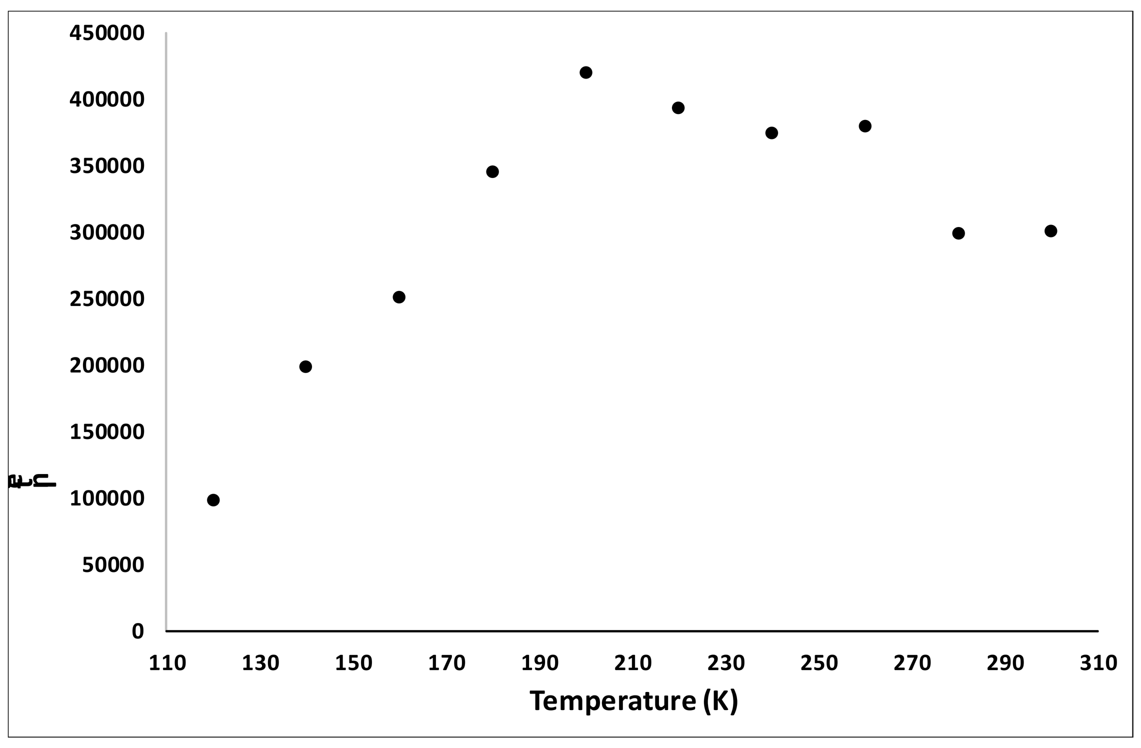

Fig. 8. Integral intensity dependence of EPR spectra of ZnO:Cu.

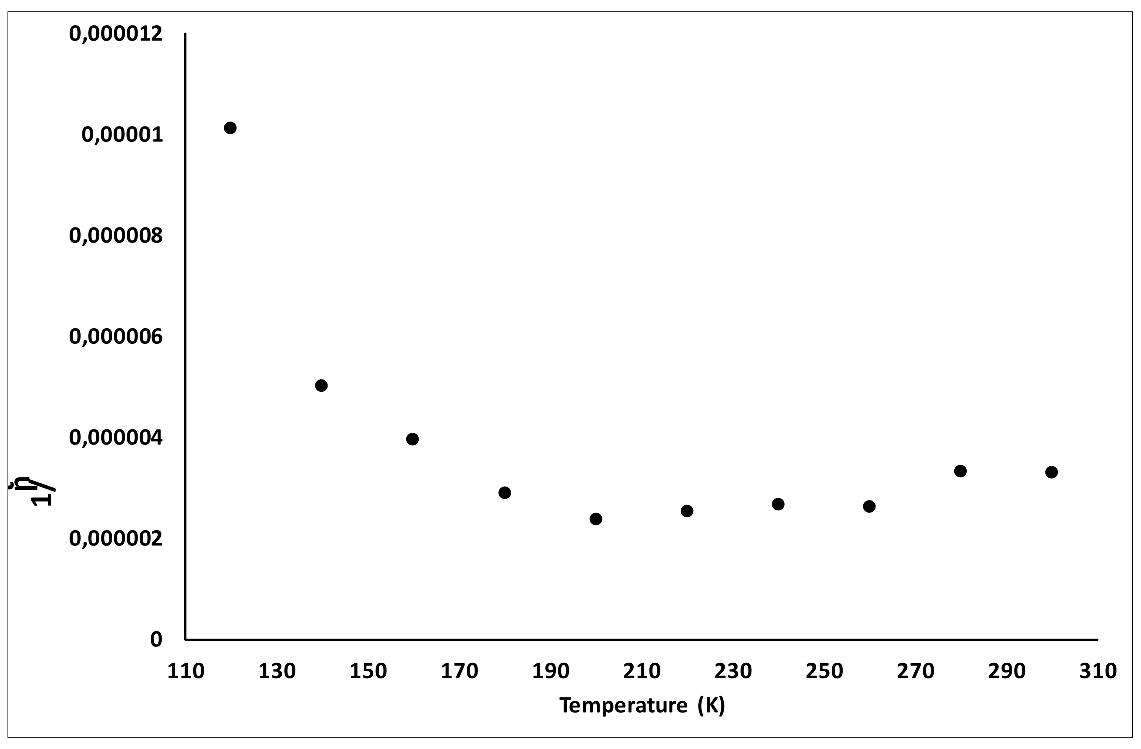

Fig. 9. Inverse of integral intensity dependence of EPR spectra of ZnO:Cu.