Synthesis and Characterizations of ZnO-Nanostructured Hierarchical Morphology on Zn Microwires

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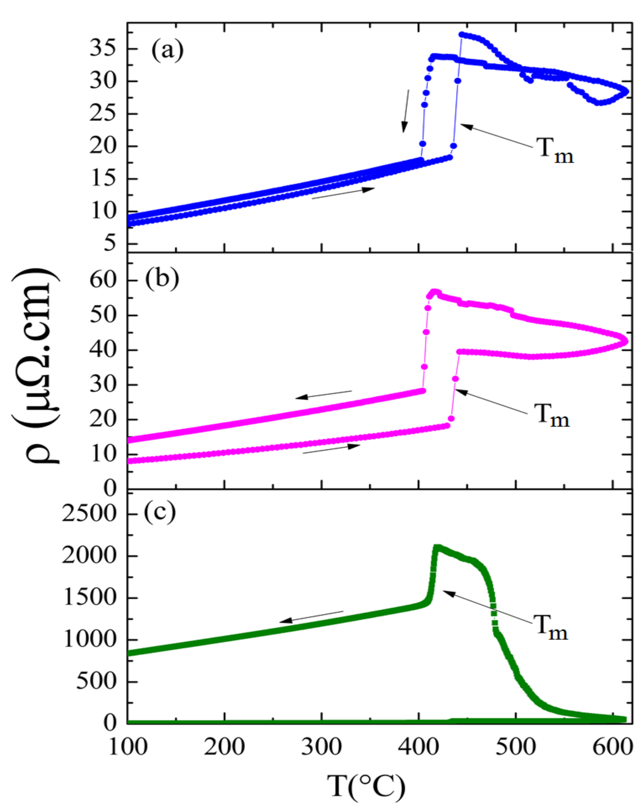
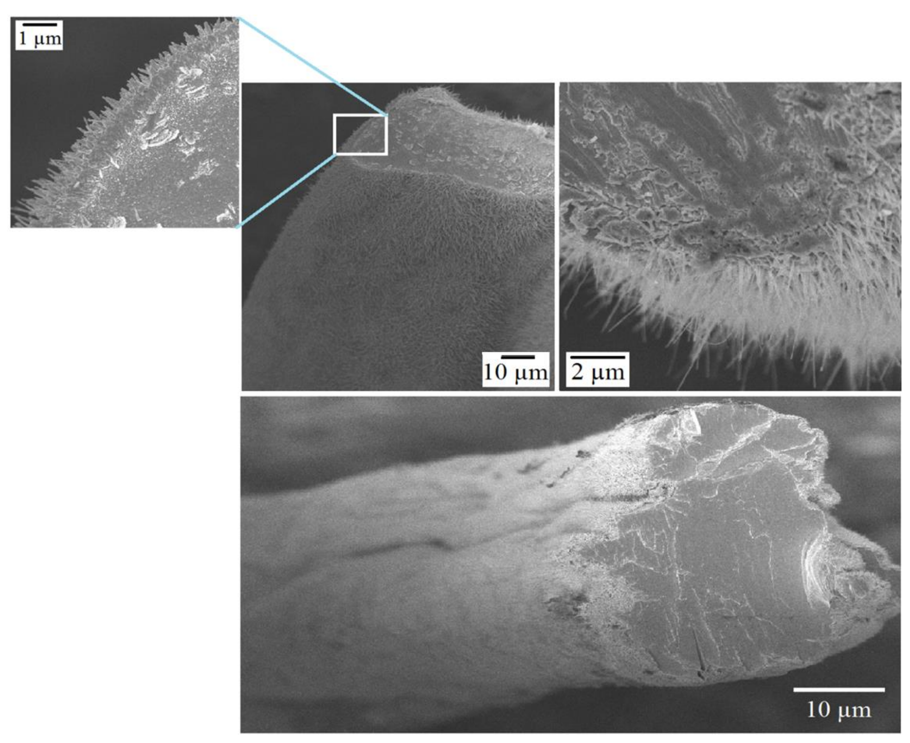
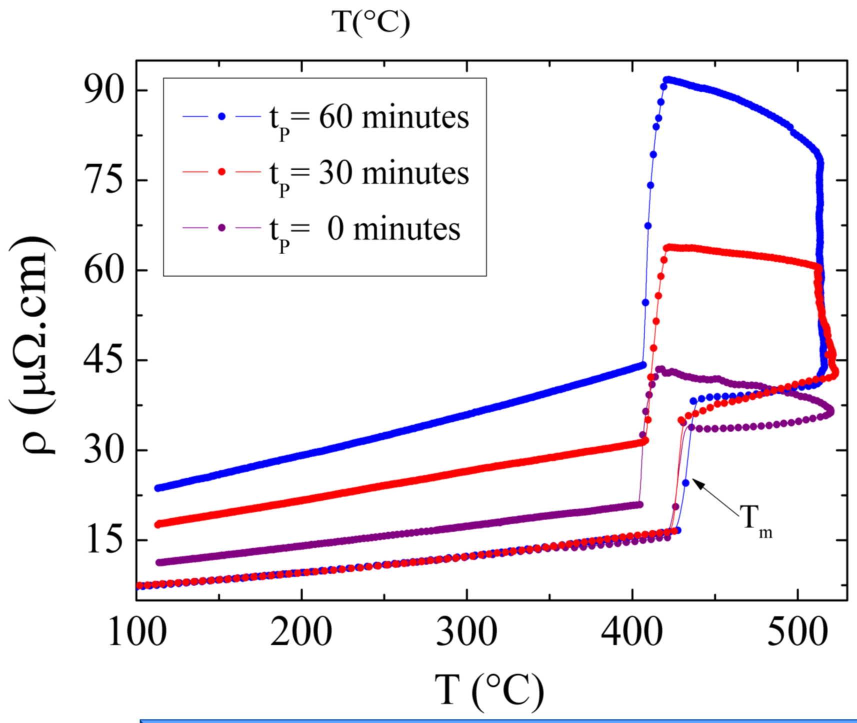
Abstract

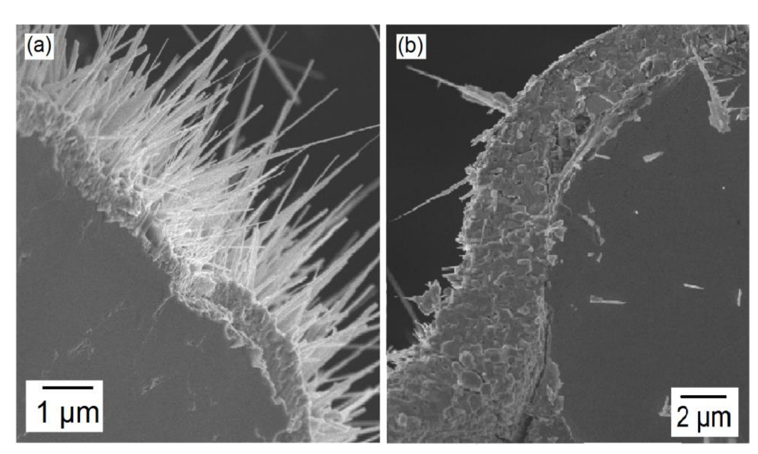
Nanostructured transition metal oxides have received much attention due to their attractive physical properties and potential technological applications. We have studied the morphological, structural, and electrical properties of metal-semiconductor (Zn/ZnO) core/shell microwires. The Zn/ZnO coaxial microwires consisted of a metallic core (Zn) and a semiconducting shell that is comprised of a ZnO thick microlayer covered with ZnO nanowires. The synthesis of the nano/microstructured ZnO shell was carried out by thermal oxidation process of Zn metal in air. This oxidation process was accompanied by *in situ* electric resistivity measurements. Characterizations of the morphological and structural properties of as-synthesized samples were performed by scanning electron microscope (SEM) and x-ray diffraction (DRX). The electrical resistivity measurements as a function of temperature and magnetic field of these Zn/ZnO core/shell coaxial microwires reveal a positive and enhanced magnetoresistance effect.

Synthesis of Zn/ZnO core/shell coaxial samples

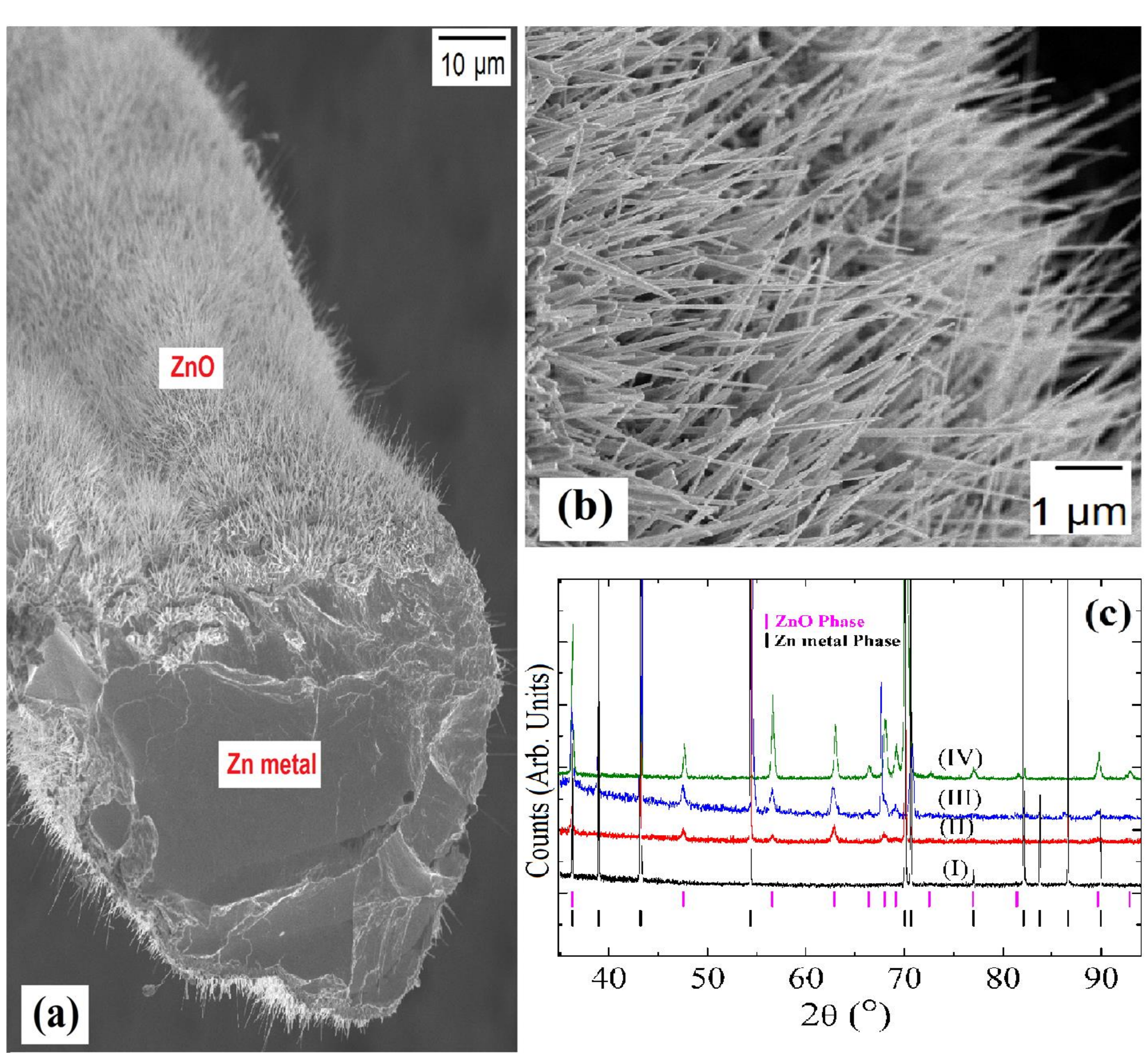








SEM and X-ray Diffraction Results



Acknowledgments

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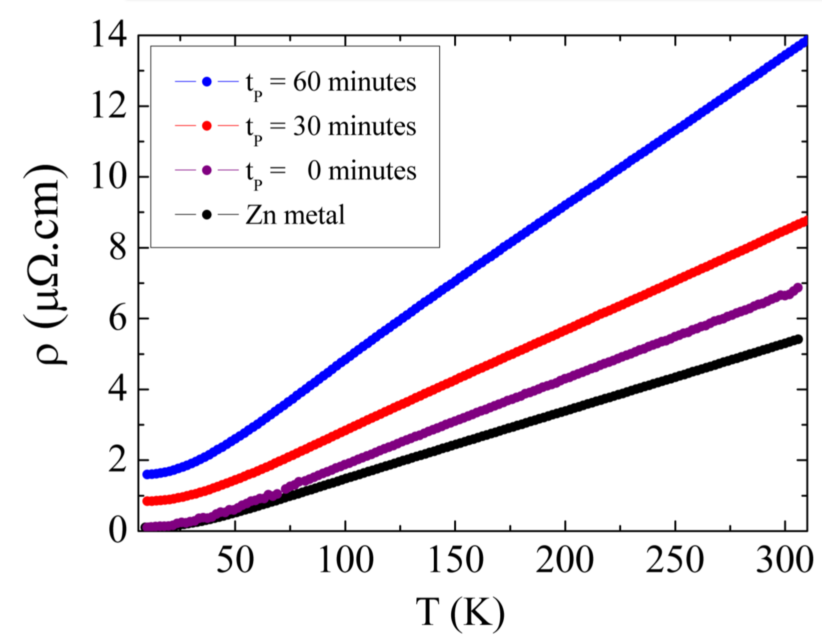
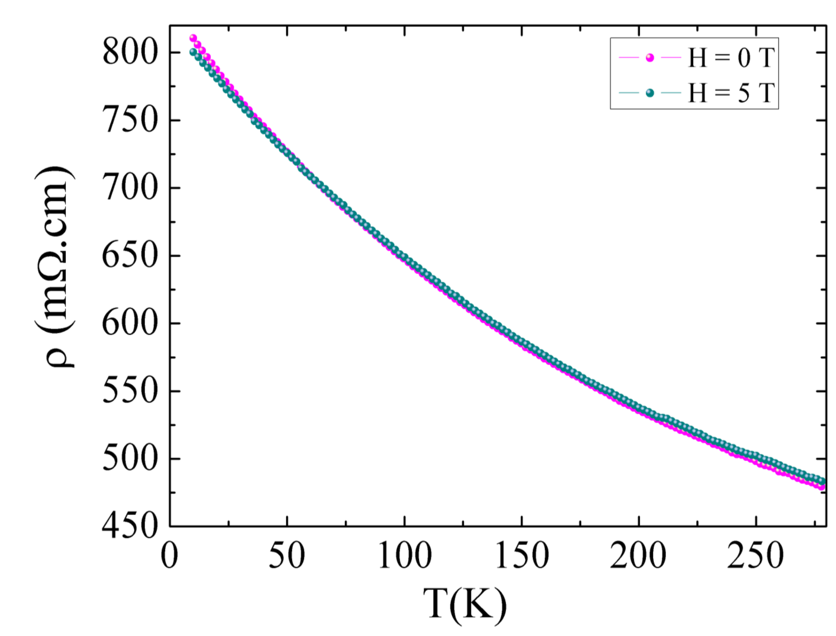
Electrical Resistivity Results



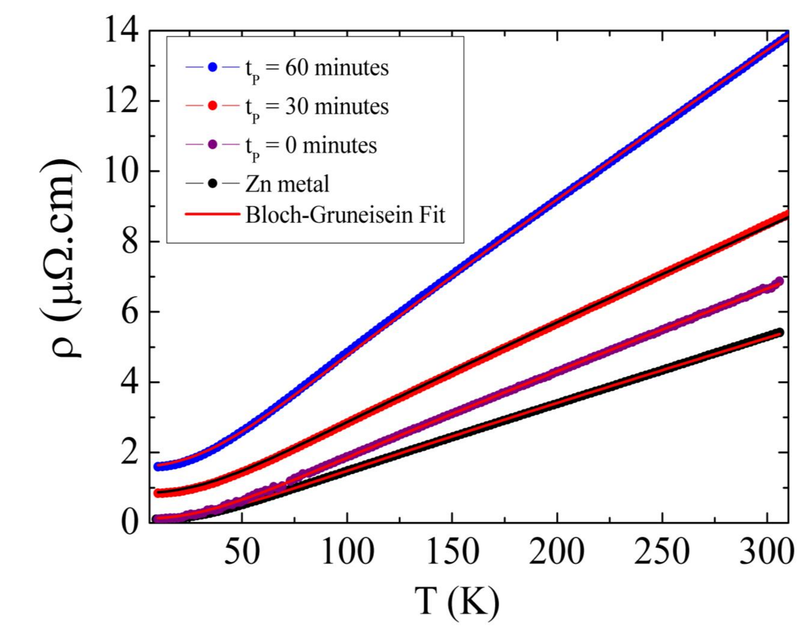


Bloch-Grüneisen Model

$$\rho(T) = \rho_0 + \rho_{el-ph}(T)$$

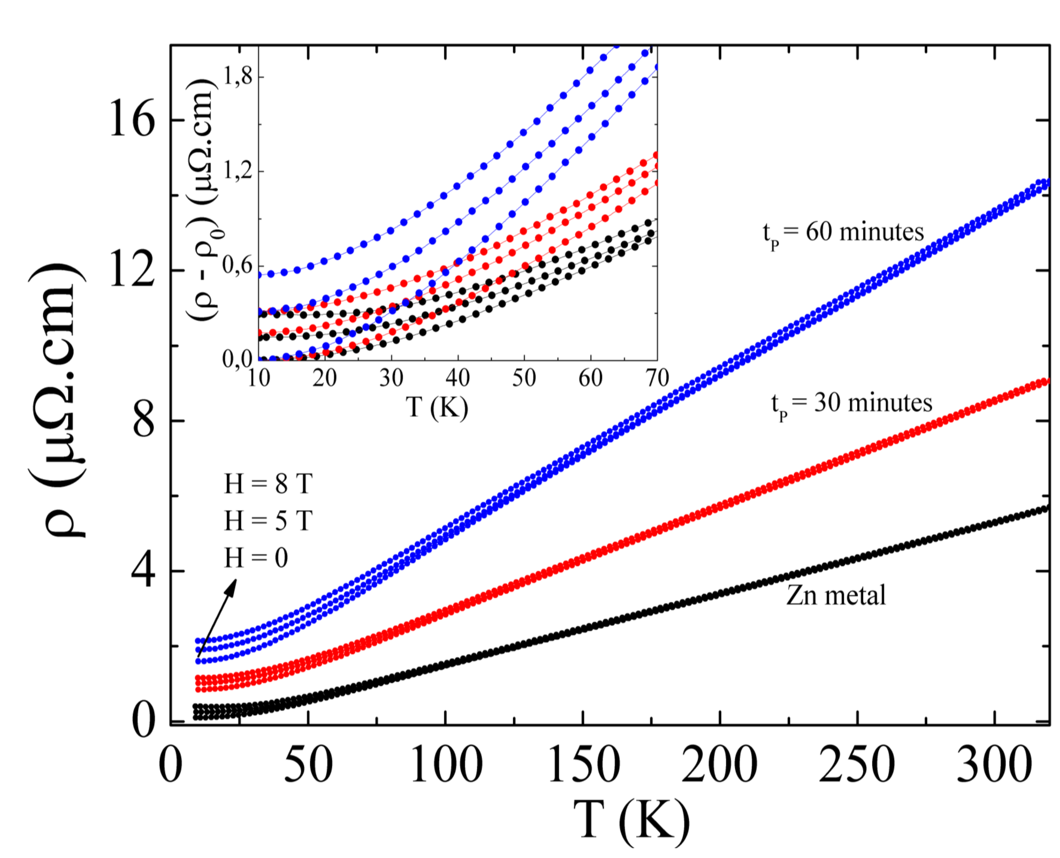
$$\rho_{el-ph}(T) = \alpha_{el-ph}\left(\frac{T}{\Theta_D}\right)^n \int_0^{\Theta_D/T} \frac{x^n}{(e^x-1)(1-e^{-x})}dx$$

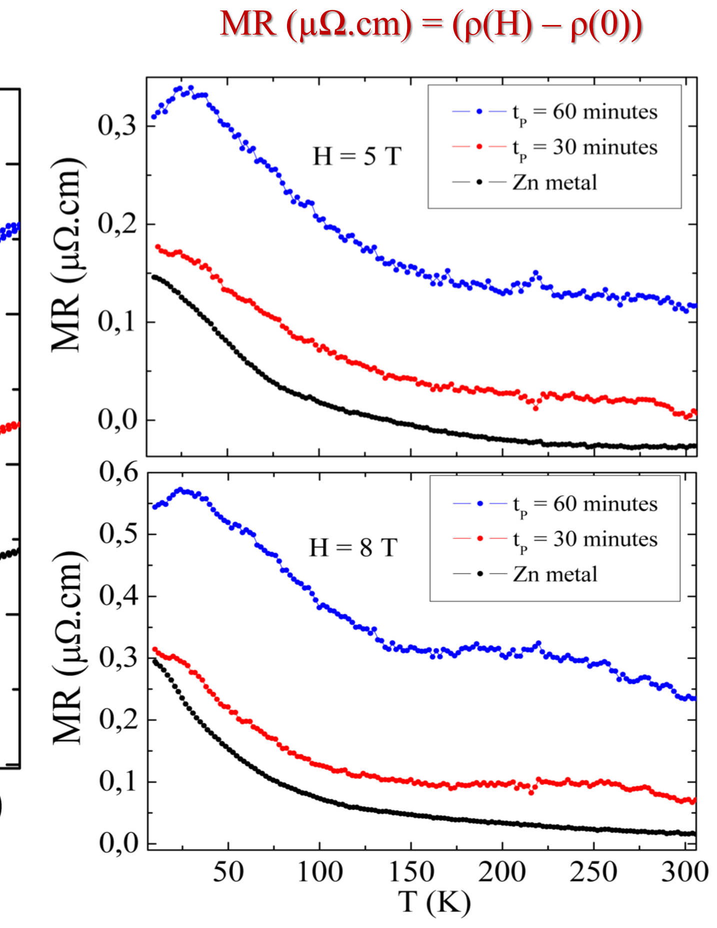
t_p (min)	ρ_0 (µΩ.cm)	α_{el-ph}
Zn metal	0.098	6.3 (3) x 10^{-6}
0	0.133	9.8 (0) x 10^{-6}
30	0.84	8.7 (4) x 10^{-6}
60	1.59	1.4 (1) x 10^{-5}



Magnetoresistance Results

MR (µΩ.cm) = (ρ(H) – ρ(0))





Conclusions

- Zn/ZnO core/shell microwires were synthesized through thermal oxidation technique;
- SEM and DRX confirmed Zn/ZnO core/shell structured samples. By increasing the waiting time, different ZnO microlayer thickness can be obtained;
- The Bloch-Grüneisen model has been used. Fixing the parameter *n* or Θ_D, the electron-phonon coupling parameter increases with increasing of ZnO microlayer thickness;
- Positive magnetoresistance effect has been observed to be lager in the samples with thicker layer and at low temperatures;
- It is suggested that an effective magnetic moment is induced in the nanostructured oxide layer which superimposes to the external magnetic field influencing the electrical transport properties in the Zn core - $B_{Eff} = H_{ex} + B_{ind}$.