Impurity-Ion pair induced high-temperature ferromagnetism in Co-doped ZnO

R. Hanafin[a], C.D. Pemmaraju[a], T. Archer[a], H.B. Braun[b] and S. Sanvito[a]
[a]School of Physics, Trinity College, Dublin 2, Ireland
[b]School of Physics, University College Dublin, Dublin 4, Ireland

9.7 cm

ZnO has been the focus, in recent years of intense scientific enquiry. Numerous experimental results reported in the literature supported early mean field predictions of a high critical temeperature for the onset of ferromagnetism. The impetus for this research arises from the hope that ZnO may sustain its apparent magnetism above room temperature and thus become a material combining semiconducting, magnetic, optical and mechanical properties, in essence the ultimate multifunctional material. Despite the experimental claims of ferromagnetism in Co doped ZnO a definitive theoretical explaination for the magnetic interaction over long range has so far been lacking. Here we present a mechanism which describes not only the origin of this previously inexplicable magnetism but also explains the experimental findings to date and suggests a recipe for tailoring the magnetic properties of ZnCoO based spintronic devices. We demonstrate that the magnetism originates from a Co2+ oxygen vacancy pair (CoV) with a partially filled level close to the ZnO conduction band minimum. The long range coupling then occurs via conduction electrons at moderate n doping. Furthermore we demonstrate how experimental findings may be explained by a combination of this proposed mechanism and superparamagnetically blocked clusters. Based upon these results we are now in a position to propose a definitive phase diagram of ZnCoO.

13.4 cm

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Corresponding author :
R. Hanafin

Address for correspondence :
Rm 210
Lloyd Building
Trinity College, Dublin, Ireland

Email address :
hanafinr@tcd.ie