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Magnetic uniformity of oxide based diluted magnetic semiconductors

Jiabao Yi
UNSW, Australia,

Diluted magnetic semiconductor is one of the materials for spintronic devices. Oxide based diluted magnetic semiconductors have attracted extensive interest due to its possible high Curie temperature. Intrinsic ferromagnetism is essential for the practical applications. However, currently, the intrinsic ferromagnetism in oxide diluted magnetic semiconductors is difficult to be determined. One of the popular ways is to use transmission electron microscopy, electron dispersive energy spectroscopy (EDS) and electron energy loss spectroscopy to identify the uniform distribution of dopants and whether there are no clusters. However, there is no direct evidence to show the magnetic uniformity in oxide based diluted magnetic semiconductors. Recently, we used low energy muon spin relaxation approach to identify the magnetic uniformity in Co doped TiO_2, Fe doped In_2O_3 and Co doped ZnO systems. Combined with other techniques, such as TEM EDS and measurement by magnetometer, we found that Co doped TiO_2 is intrinsic with magnetic uniformity when Co doped TiO_2 was deposited with relative high rate under an oxygen partial pressure of 10-6 torr. The uniformity will disappear if the deposition rate is relatively low. For Co doped ZnO, the samples deposited under different oxygen partial pressures does not induce clustering or secondary phase. Dopants are uniformly distribution in the ZnO host. However, muon spin relaxation measurement indicates that the samples do not show magnetic uniformity. Bound magnetic polarons formation is the origin of ferromagnetism, supported by resistance measurement. For Fe doped In_2O_3, clusters are observed in the sample deposited under an oxygen partial pressure of 10-7 torr. X-ray absorption spectroscopy indicate the clusters are Fe_3O_4, but on metallic Fe. In addition, muon spin relaxation and polarized neutron diffraction all indicate the Fe doped In_2O_3 via substitution dominates the contribution of ferromagnetism and the magnetization is higher than Fe_3O_4 clusters, suggesting that clustering is not the major origin of ferromagnetism. The work has shown that the mechanisms of different oxide based diluted magnetic semiconductor may be varied. We have to investigate one by one.

jiabao.yi@unsw.edu.au