

Investigating the Valence Band Structure of (Ga,Mn)As

Intikhab Ulfat

Department of Physics, University of Karachi, Pakistan

The origin of ferromagnetism in dilute magnetic semiconductors remains an issue of debate [1]. Two main scenarios are discussed: acceptor induced holes in the host valence band and holes in an impurity band. Experimental evidence for the existence of an impurity band based on optical properties has been presented [2], though later studies suggest that the data are consistent with the valence band model [3]. Support for an impurity band scenario is also obtained from resonant tunneling experiments on quantum well structures [4]. Two other recent studies, one based on channeling in combination with magnetization, transport, and magneto-optical experiments [5], the other on hard X-ray photoemission [6], have come to different conclusions: the first one supporting an impurity band model in which the location of the Fermi level within the impurity band plays a crucial role in determining the Curie temperature (TC), the second emphasizing the coexistence of coupling mechanisms in the impurity band and host valence band models. It is clear that further reliable experimental work is needed to clarify the situation and provide directions for systematic procedures to find the optimally stabilized ferromagnetic state.

Our recent work on Mn-doped GaAs has revealed new unexpected features, including a spin polarized energy band with strong in-plane dispersion, extending slightly above the VBM of GaAs. Very surprisingly, similar observations are made above and below the Curie temperature of (Ga,Mn)As (typically 70K for as-grown samples). Since the band structures of the para- and ferromagnetic states are predicted to be distinctly different [7], even if the exchange splitting is very small [3], this result is not compatible with the currently accepted view of (Ga,Mn)As. The combined information gathered so far indicates that there exists a ferromagnetic surface layer on (Ga,Mn)As even at room temperature.

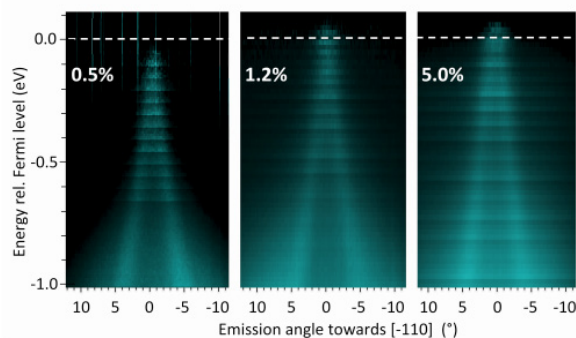


Fig. 1: Intensity distribution near VBM

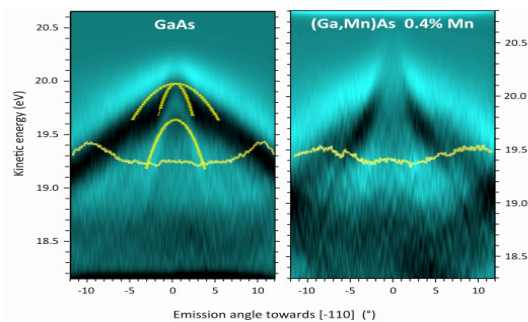


Fig. 2: VBM data for GaAs and (Ga,Mn)As

References

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