

# Novel energy-band model for semiconducting spintronics material gallium manganese arsenide

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(PhysOrg.com) -- The Fermi level position and band structure of gallium manganese arsenide has been determined for the first time, shedding light on the precise mechanism behind ferromagnetism in the material.

The University of Tokyo announced on February 7, 2011 that Professor M. Tanaka and his colleagues have succeeded in determining the Fermi level position and [band structure](#) in semiconducting [spintronics](#) material gallium manganese arsenide (GaMnAs) by a unique method combining a precise etching technique and resonant tunneling spectroscopy. Details were presented in [Nature Physics](#).

A ferromagnetic semiconductor is a basic material for spintronics which utilizes "electron spin" to realize new functional devices. Although GaMnAs is such a typical ferromagnetic material, its band structure has been controversial. Prevalent model assumes a valence band merged with an impurity band due to Mn atoms, with the Fermi level located inside the band and holes contribute to electrical conduction. However, optical study has shown that the Fermi level is located outside of valence band.

In this work, layers of 100nm thick beryllium-doped gallium arsenide (GaAs), 5nm thick aluminium arsenide tunnel barrier and GaMnAs were grown successively on a (001) GaAs substrate. The GaMnAs layer is etched to various thickness of 4.6-22nm to make quantum wells of different thickness between the surface and the tunnel barrier. Resonant

tunneling spectroscopy, applied to a variety of surface GaMnAs layers, can elucidate the valence-band (VB) picture of GaMnAs. The VB structure of GaAs is almost perfectly maintained and does not merge with the impurity band for any of the GaMnAs samples, with manganese concentrations ranging from 6 to 15%. Furthermore, the exchange splitting of the VB is found to be very small (only several milli-eV), even in GaMnAs with a high Curie temperature (154K).

Researchers suggest that their findings shed light on the precise mechanism behind [ferromagnetism](#) in GaMnAs; a subject that has been debated for more than a decade.

**More information:** Shinobu Ohya, Kenta Takata & Masaaki Tanaka, "Nearly non-magnetic valence band of the ferromagnetic semiconductor GaMnAs", *Nature Physics* (2011) [DOI:10.1038/nphys1905](https://doi.org/10.1038/nphys1905) . Published online 06 February 2011.

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