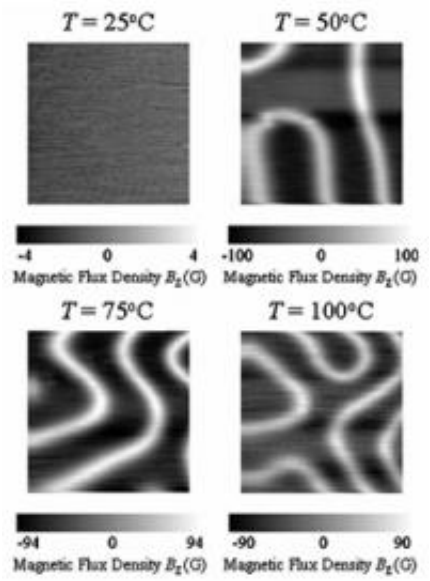
Hall effect magnetic field sensors for high temperatures and harmful radiation environments

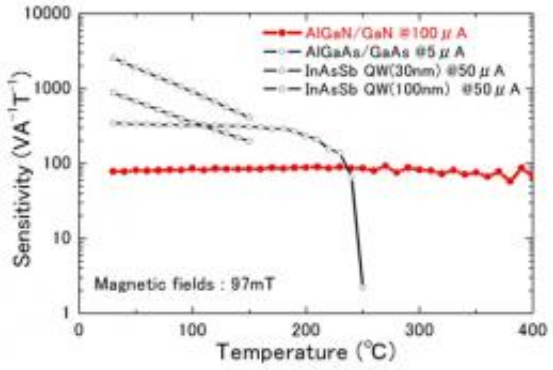
March 22 2012, By Adarsh Sandhu



SHPM images of a bismuth substituted iron garnet thinfilms at 25-100 °C under an external perpendicular magnetic field Hext of150 Oe. Credit: Toyohashi University of Technology

Toyohashi Tech researchers have fabricated Hall effect magnetic field sensors operable at least 400 C and in extreme radiation conditions using gallium nitride-based heterostructures a with two-dimensional electron gas.

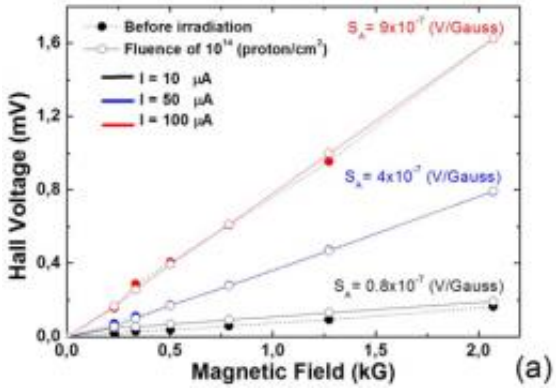
Silicon and III-V compound semiconductor Hall effect magnetic field sensors are widely used in the electronics industry for monitoring rotation in equipment such as optical memory disks and for banknote authentication in vending machines. However, the use of Hall sensors for monitoring magnetic fields in outer space and nuclear power stations is more challenging because of the large fluctuations in temperature and harmful radiation in these environments.



Temperature dependence of current-related magnetic sensitivity. Credit: Toyohashi University of Technology

To resolve these issues, the Toyohashi Tech researchers used AlGaN/GaN two-dimensional electron gas heterostructures to fabricate high sensitivity micro-Hall effect magnetic field sensors that are stable at high temperatures and high fluxes of proton irradiation.

Notably, the AlGaN/GaN micro-Hall sensors were stable up to at least 400 C, whereas sensors fabricated using the GaAs and InSb degraded from ~120 oC.



Variation of Hall voltage with magnetic field with drive current for an AlGaN/GaN Hall sensor before and after irradiation with proton fluence of 10 14 cm-2. Credit: Toyohashi University of Technology

Furthermore, the electron mobility and two dimensional electron density of the AlGaN/GaN micro-Hall sensors were only slightly affected by a $1x10^{13}$ cm^{-2} proton dose at 380 keV.

The researchers are actively seeking industrial partners to explot the robust properties of the 2DEG-AlGaN/GaN 2DEG Hall sensors for operation at high temperatures and in harsh radiation environments.

A potential application included imaging of ferromagnetic domains at the surface of permanent magnetics. Adarsh Sandhu has demonstrated the imaging of magnetic domains in ferromagnetic materials with a AlGaN/GaN micro-Hall sensor in a high temperature scanning Hall probe microscope (SHPM).

More information: 1. S. Koide, H. Takahashi, A Abderrahmane, I. Shibasaki, A.Sandhu, High Temperature Hall sensors using AlGaN/GaN HEMT Structures, Institute of Physics Journal of Physics Conference Series (in press)

2. T. Yamamura, D. Nakamura and A. Sandhu, High sensitivity and quantitative magnetic field measurements at 600°C. J. Appl. Phys. 99, 08B302 (2006)

3. Z. Primadani, H. Osawa, and A. Sandhu, High temperature scanning Hall probe microscopy using AlGaN/GaN two dimensional electron gas micro-Hall probes. J. Appl. Phys. 101, 09K105 (2007).

Provided by Toyohashi University of Technology