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Research highlights

Hard electronics: Nitride semiconductor Hall effect magnetic field sensors for extreme environments

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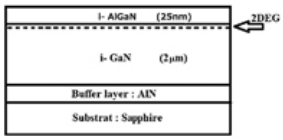
Hall effect magnetic sensors made of silicon, indium arsenide, and gallium arsenide are widely used to monitor the rotation of moving parts in automobiles and personal computers, as well as more innovation applications including mapping magnetic fields by scanning Hall probe microscopy, and detection of nanomagnetic labels biomedical diagnostics and biomolecular recognition.

However, the performance of Hall sensors fabricated using these small bandgap semiconductors deteriorates drastically at high temperatures and in the presence of high energy radiation. Thus these conventional semiconductor Hall sensors are not applicable for increasing important applications in space exploration, particle accelerators, and thermonuclear power stations.

Here, researchers in Japan at the Electronics Inspired Interdisciplinary Research Institute (EIIRIS) colleagues at Toyohashi University of Technology (Toyohashi Tech) and Quantum Beam Science Directorate, Japan Atomic Energy Agency (JAEA), Takasaki describe the properties of AlGaN/GaN micro-Hall sensors exposed to high energy protons and demonstrate the feasibility of using these robust devices for 'hard electronics' in space and high radiation environments.



Structure of AlGaN/GaN heterostructor

The AlGaN/GaN heterostructure micro-Hall sensors were fabricated by metal organic chemical vapor deposition, and the sheet carrier density and electron mobility at room temperature were 7.36 x10 cm^{12} and 1775 cm^2/Vs, respectively. Unpackaged sensors were irradiated with 380 keV protons and fluencies of 10^{14}, 10^{15}, and 10^{16}(proton/cm^2).

The performance of Hall sensors irradiated with 10^{14} protons/cm^2 was unaffected by the exposure to the protons. However, the resistance of sensors exposed to higher fluences increased, showed degradation due to the formation of defects and traps in the GaN layer. Notably, annealing restored the electrical characteristics of these devices due to the rearranging atoms in the GaN.

The sensors are expected to find applications in extreme environments, where device packaging will protect them against higher proton fluences.

Reference:

Authors: A. Abderrahmane, S. Koide, H. Okada, H. Takahashi, S. Sato,* T. Ohshima,* and A. Sandhu
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