IN THE HEART OF THE REACTOR: TESTING GRAPHENE FOR NEUTRON-RESILIENT ELECTRONICS

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As the urgency of climate change accelerates, nuclear fusion emerges as a promising long-term energy solution. Among fusion technologies, magnetic confinement systems like tokamaks rely heavily on accurate magnetic field diagnostics. This work explores the development of Hall effect graphene-based magnetic sensors designed to operate in the extreme conditions found inside fusion reactors.

The research focuses on the performance of graphene-based sensors exposed to high temperatures and neutron radiation—two key stressors in fusion environments. To fabricate the sensors, hydrogen-intercalated quasi-free-standing (QFS) graphene was grown on semi-insulating 4H-SiC(0001) and 6H-SiC(0001) substrates and then coated with a protective Al2O3 layer [1, 2]. Neutron irradiation experiments were carried out at the MARIA reactor, operated by the Polish National Center for Nuclear Research [3, 4], while thermal effects were evaluated in a separate study [5].

Measurements using the Hall effect, micro-Raman spectroscopy, and density functional theory indicate that the primary cause of performance degradation after irradiation is the loss of hydrogen from the intercalated layer. This hydrogen depletion disrupts the unique electronic properties of QFS graphene. However, the research also shows that thermal annealing above 200°C can partially reverse this damage—likely through hydrogen diffusion at elevated temperatures. The effectiveness of recovery depends on how much hydrogen was lost during irradiation [4]. Understanding these degradation and recovery mechanisms is essential for assessing the long-term viability of graphene-based sensors for magnetic diagnostics in fusion reactors and other high-radiation environments

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References

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