Design and Perfomance of Metal Hall Sensors

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Hall sensors with their small dimensions, simple principle of operation, and linear dependence of output voltage on measured magnetic field, offer an attractive non-inductive method of magnetic field measurements for ITER tokamak and future fusion reactors. Their use for steady state magnetic diagnostics is presently limited by several issues related to their radiation and thermal stability. Previous studies on semiconductor type Hall sensors showed that the commercially produced Hall sensors are insufficient as they cannot satisfy even ITER ex-vessel environment requirements [1]. Specially produced semiconductor-based Hall sensors made by MSL Lviv seem to be more suitable for this environment. These InSb based sensors showed good radiation resistance up to the total neutron fluence of at least $10^{18}\,cm^{-2}$ [2]. Despite the optimistic forecast for ITER ex-vessel applications, the semiconductor-based radiation hard Hall sensors will probably not be capable to satisfy requirements posed by ITER in-vessel environment (neutron flux about 3 orders of magnitude higher) and by far also those posed by future DEMO reactor. Alternative option to semiconductor-based Hall sensors could be those based on metals. The supposed higher radiation hardness of the metal based Hall sensors is paid for by somewhat lower sensitivity compared to the semiconductor ones. As a result, metals are only very rarely used for producing commercial Hall sensors and the knowledge of properties of such sensors is rather limited if any.

Consequently, the aim of this contribution will focus on metal Hall sensors design, construction, as well as description of parameters of such sensors, e.g., offset voltage, sensitivity and its dependence on temperature, input and output resistivity, and performance of the sensors after temperature cycling. If experimental schedule allows, also comparison of sensors' characteristics before and after irradiation at LVR-15 experimental fission reactor will be presented. The sensors are designed as thin (~50 nm) bismuth or copper active layer deposited on AlN or Al_2O_3 DBC substrates with etched 0.127 mm thick copper contact areas. Bismuth was chosen as a metal with highest Hall coefficient, copper because of its high melting point. Further, electrical contacts between sensors and conductors will be made by ultrasonic bonding. Results of investigation of stability and reliability of this type of electrical contacts after high temperature cycling and irradiation will be also a part of the proposed contribution.

[1] I. Bolshakova t al.: Performance of Hall Sensor-Based Devices for Magnetic Field Diagnosis at Fusion Reactors, Sensor Letters **5** (2007), p.283-288.
[2] I. Bolshakova et al.: Instrumentation for Hall sensor testing in ITER-like radiation conditions, proceedings of 36th EPS Conference on Plasma Physics, ECA Vol.33E, *P4.169,* 29 June – 3 July, 2009, Sofia, Bulgaria.