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Development of GaAs/AlGaAs Micro Hall Sensors for Magnetic Flux Leakage Measurements

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Abstract: Magnetic flux leakage (MFL) technique is one of the most widely used Non-destructive evaluation (NDE) techniques for detection of surface and sub-surface defects in ferro-magnetic materials. Magnetic Hall sensors are preferred in such applications for their ease of use and linear response with magnetic field. GaAs/AlGaAs hetero-structure based Hall sensors are new generation of sensors with higher sensitivity (~1000 V/AT). Photolithographic patterning technique is very useful for miniaturization of Hall sensors. This paper discusses the development of 2-dimensional electron gas (2-DEG) GaAs micro-Hall sensors by photolithographic technique.

The micro-Hall sensors developed have an active area of 50μm×50μm. The sensor is fabricated using a five mask photolithographic process which includes (a) Alignment marks using (Cr/Au); (b) Wet chemical etching for device isolation; (c) Ohmic contacts using AuGe/Cr/Au metallisation followed by a rapid thermal anneal; (d) Interconnect metallisation using Cr/Au; (e) A passivation layer of photoresist followed by a hard bake. A series of sensors have been fabricated using this procedure. The fabrication process is optimized for obtaining good yield.

The fabricated sensors are calibrated from 0-100 Oe field range and the response is found to be linear with increasing field. The sensitivity obtained using this sensors is of the order of 1000V/AT, which is an order of magnitude more as compared to that obtained using the conventional Hall sensors made of Silicon or GaAs (~100V/AT). The temperature coefficient of sensitivity of the sensors is measured and it is found to be 0.15%/^{o}C between 30ºC to 90ºC.

The performance of the micro-Hall sensors for non destructive detection of leakage magnetic fields from machined notches in carbon steel plates has been studied. The results indicate that the micro-Hall sensors developed have shown good capability for detection of leakage flux from surface and sub-surface defects. In this paper, principle of MFL technique and fabrication steps, optimization of process parameters, and verification of performance of sensors are discussed. The possible applications of these indigenously fabricated sensors and issues concerning packaging the sensors for their use in field conditions are highlighted.

Keywords: *Magnetic flux leakage, micro-Hall sensor, Carbon steel*