Measurement and Calculation of Thermal Behavior in GaN-based HFET Devices

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The most important aspects of GaN-based devices are high breakdown field and high operating temperature. One high-speed device structure is the HFET (heterojunction field effect transistor) where two-dimensional electron gas (2DEG) is formed on AlGaN/GaN heterointerface. The electrons in 2DEG have significantly higher mobility than that in the conduction channel of a conventional metal-semiconductor field effect transistor (MESFET). Traditionally, GaN-based devices are fabricated on sapphire substrates. Since the sapphire substrate has relatively low thermal conductivity (0.28 W/cmK) [1], it is necessary to carry out thermal analysis to ensure that the peak operating temperature of the device is within the acceptable range. Much effort has been exerted to provide sufficient thermal analysis in the past [2]. In this paper, we present our thermal simulation using codes previously developed based on analytical solutions in our laboratory [3] and compare the result of thermal simulation to actual thermal measurement results using nematic liquid crystal. Thermal simulation results agree reasonably well with measurement profiles. At the Input I_d of 133.42mA and V_d of 6.5Volts with gate bias of –1.1Volts, the peak temperature 164°C occurs at the gate region. For the device with a total gate width of 194μm and 0.8μm gate length.

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[1] Thermal Conductivity of Solids at Room Temperature and Beloq (Boulder, CO: National Bureau of Standards, 1973)

[2] D.L Waller L.R. Fox, and R.J. Hannemann, "Analysis of Surface Mount Thermal and Thermal Stress Performance," IEE Trans Components, Hybrids, and Manufacturing Technology, Vol. 6, September 1983, pp. 257-266

[3] David H. Chien, Chen Y. Wang and Chin C. Lee "Temperature Solution of Five-Layer Structure with a Circular Embedded Source and Its Applications", IEEE Trans. CHMT- 15, October 1992, pp. 707-714

본 연구는 2001 년 명지대학교 교원 해외파견사업의 지원으로 이루어졌음.