High-Efficiency GaN HEMT for 2.45 GHz Microwave Heating Applications at 300 W

1. Outline

In recent years, the use of microwaves for heating applications has been expanding, not only in consumer applications such as food heating in microwave ovens but also in industrial processes including food processing, drying of materials like wood and resins, as well as plasma generation in semiconductor equipment. Traditionally, magnetrons have dominated the field of microwave heating due to their low cost and high output as vacuum tube components. However, Gallium Nitride High Electron Mobility Transistors (GaN HEMTs) have garnered attention in recent years due to their long lifespan, high reliability, and low noise characteristics. Additionally, GaN HEMTs offer high controllability of phase, frequency, and output power, enabling the realization of new heating functions such as uniform heating and selective heating.

Against this backdrop, there is a growing interest in the use of GaN HEMTs for microwave heating applications; however, achieving high output and high efficiency that can rival magnetrons in properties has been a challenge. In this report, we present the development of a 300 W high-efficiency GaN HEMT for the 2.45 GHz band.

2. Features

2-1 Device design

Unlike applications for communication and radar, microwave heating applications require devices to operate continuously at high power. As a result, the heat generated in GaN dies is significant, making the heat dissipation design of the devices crucial. We developed a GaN die for heating applications that reduces thermal resistance by approximately 15% compared to conventional designs, allowing us to design devices capable of withstanding high output and continuous operation.

The developed 300 W GaN HEMT for the 2.45 GHz band is shown in Photo 1. The package size is 20.6 mm × 15.6 mm. Inside the package, a matching circuit composed of ceramic capacitors and wires is implemented with the GaN die, ensuring proper matching for achieving high efficiency. The evaluation fixture is shown in Photo 2. The patterns on the fixture and the chip capacitors were designed to yield a 50 Ω impedance at the connector end.

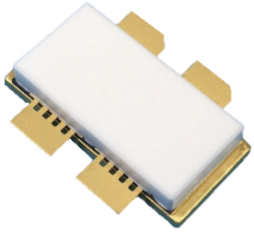

Photo 1. Appearance of the 300 W GaN HEMT for the 2.45 GHz band

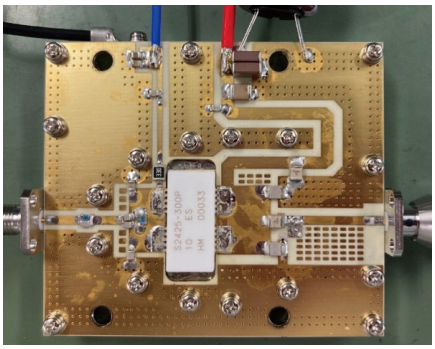

Photo 2. Evaluation fixture for the 300 W GaN HEMT at the 2.45 GHz band

2-2 Device performance

Figure 1 shows the radio frequency (RF) characteristics of the 300 W GaN HEMT for the 2.45 GHz band. The operating conditions are a drain voltage of 50 V, continuous wave operation, and an input power of approximately 37 dBm (5 W). The output power achieved in the 2.4–2.5 GHz band is between 54.8–55.1 dBm (300–320 W) with a drain efficiency of 77%. This represents the highest efficiency reported to date for a 2.45 GHz band GaN HEMT operating continuously at the 300 W level. Additionally, the efficiency is comparable to or greater than that of magnetrons currently used in the market, which is expected to accelerate the adoption of GaN HEMTs for microwave heating applications.

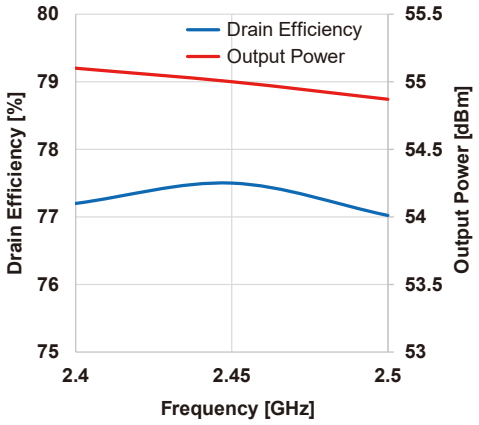

Fig. 1. RF characteristics of the 300 W GaN HEMT at the 2.45 GHz band