MwT's GaAs Device Technology

MicroWave Technology Inc. was established in 1982 by two senior technologists with years of hands-on experiences in Gallium Arsenide (GaAs) epitaxial material growth and microwave device design and processes. The company has used both in-house grown proprietary VPE (Vapor Phase Epitaxy) material and external MBE (Molecular Beam Epitaxy) material as device starting materials. The in-house GaAs fab offers a number of GaAs device technologies and processes, including high linearity MESFET with excellent power added efficiency, low noise MESFET, low phase noise MESFET, PHEMT, as well as X-band and K-band Gunn diodes. A family of MwT GaAs devices with various gate widths offer linear output power from 10 milliwatts to 4 watts. MwT devices can be used from a few MHz to 32 GHz in operation frequencies. The FET devices use germanium-nickel-gold alloys as metal for good source and drain ohmic contacts and refractory metal for reliable gate and "mushroom" shaped plated gold to reduce gate resistance. The gate is recessed below the GaAs surface to ensure good high frequency performance and avoid surface related reliability issue. MwT devices have two nominal gate lengths, 0.3 microns and 0.8 microns, depending on the frequency requirements for the specific applications. All devices are passivated with patented impervious diamond-like carbon and silicon nitride passivation system. All the bonding pads and air-bridges are formed with thick layer of plated gold.

The MwT devices use propriety doping profiles combined with process technology to achieve high linearity. With continues improvement in device design and proper circuit design, power amplifiers using MwT linear devices can achieve excellent linearity performance. For example, a large separation of 19–20 dBm can be achieved between the linear output power, P_{1dB}, and the Third Order Inter-Modulation Intercept Point, IP3. This kind of state-of-the-art linearity performance is among the best of any commercial linear semiconductor devices available today. Consequently, amplifiers using MwT linear devices show superior Adjacent-Channel-Power-Ratio, or ACPR, which is a highly desirable characteristics required by broadband wireless/wired communications to assure high data transmission rate.

MwT's main fabrication facility (Nitride deposition process)

The MwT devices also achieve excellent performance in low noise amplifier (LNA) applications. LNA's using MwT devices exhibit high dynamic range, which means the low noise figure, high linearity and ample output power can be achieved simultaneously in the LNA. The high dynamic range for high date receivers is another important characteristic demanded by wireless infrastructure applications.

With thorough understanding of the principles that would impact device phase noise characteristics, the device physicists at MwT optimized the epitaxial material and device process to further improve the phase noise performance. High frequency oscillators from 10 GHz to over 20 GHz using MwT low phase noise devices can achieve the state-of-the-arts phase noise performance. For example, excellent phase noise power density of 130 dBc/Hz at 100 kHz offset was demonstrated by 10 GHz DRO (Dielectric Resonant Oscillator) using MwT low phase noise device. A related device characteristic is low amplitude noise at low frequency range. Amplifiers using MwT device also show excellent low amplitude noise figure in frequencies below 100MHz, an important frequency band for many industrial applications.

The X-band and K-band GaAs Gunn diodes made by MwT with proprietary doping profile and processes also show excellent chirp property and output efficiency in Gunn based oscillators.

After wafer fabrication, devices on

each wafer is 100% DC probed and devices outside the electric specifications are inked. The wafer then goes through scribing and die separation. A pick-place machine will automatically pick the good dice and sort them into discrete current ranges (Bins) based on the DC probing data. Samples from each wafer will also go through a rigorous qualification process, including RF testing, bond pull test, die shear test, storage burn in and dynamic burn in. Wafers failed during those qualification processes will not be allowed to ship to customers or placed into FGI. Wafers passing the qualification will go through die visual inspections and devices are classified into several visual levels defined by internal visual criteria based on mil standard.

MwT also offers screen, inspection, testing, and burn-in for high-rel jobs on devices for space qualified applications in both chip form or packaged form. MwT high-rel devices have been used for space applications in the past 12 years.

The long-term reliability of MwT GaAs device technology was arrived by stressing the devices at elevated temperatures with biases and measuring the degradations of the key device parameters. The results from the accelerated stress established the relationship between device MTTF (Mean-Time-Toward-Failure) and device channel temperature. Based on the relationship (the Arrhenius Plot), one can extrapolate the mean life of the MwT devices to be around $1x10^6$ hours (114 years) at device channel temperature of 150C, or $3.5x10^5$ hours (40 years) at device channel temperature of 160C. The Arrhenius Plot of MwT devices is attached.

A unique reliability feature of MwT devices is that the devices are hydrogen proof. Since most of other manufacturer's devices use Platinum (Pt) in its gate metal structure. Once hydrogen was absorbed by Pt in the gate metal layers, the long-term performance and reliability of the device will degrade due to alteration of the Schottky barrier height. MwT devices will not be poisoned by hydrogen because the device does not use Platinum (Pt) in its gate metal structure.

MwT's wafer fabrication (photolithography)

Carefully designed experiments examined the hydrogen effect on MwT devices and concluded that they are NOT sensitive to the presence of hydrogen at elevated temperatures. This unique property makes MwT device an excellent candidate for high reliability applications required by defense and space microwave programs. An application note on the Evaluation of Hydrogen Effects on MwT's FETs is available for review upon request.

MTBF Plot for Mwt GaAs FET