MicroWave Technology

4268 Solar Way
Fremont, CA 94538
(510) 651-6700
FAX (510) 651-2208

GaAs FET APPLICATION NOTE

Evaluation of The Effects of Hydrogen on MWT's FETs

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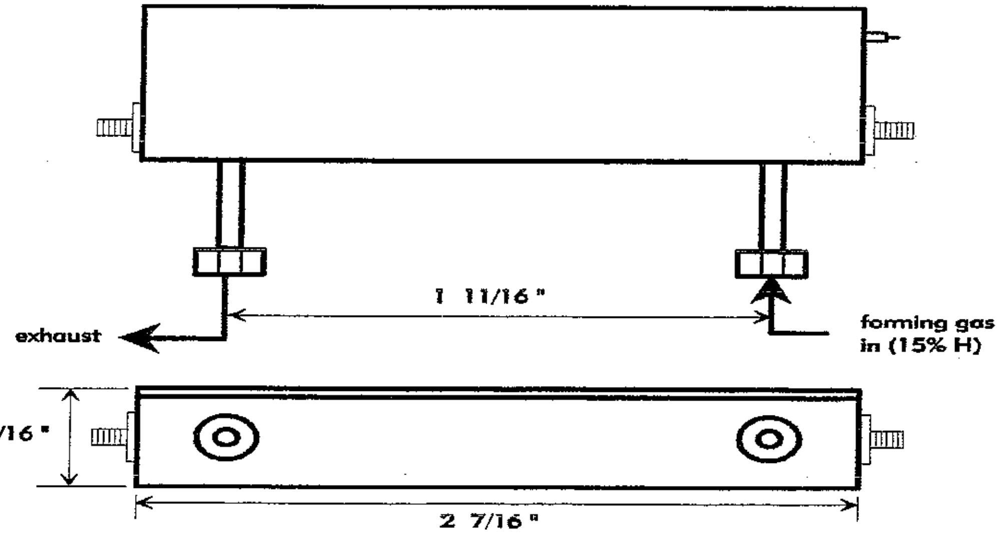
BACKGROUND

A number of articles [1],[2] both in the literature and reported at conferences[3],[4] have described the possible deleterious effects of hydrogen on the long term performance and reliability of FETs. The situations described demonstrated that under certain conditions, the presence of hydrogen in a sealed housing can result in premature degradation of both the DC and RF performance of FETs contained in the housing. It has been theorized that the degradation is associated with the presence of platinum and/or palladium metal in the FET gate structure. As Microwave Technology's (MWT) FETs do not use platinum or palladium in their gate metallization structures, it was presumed that MWT's FETs will not exhibit this degradation in the presence of hydrogen.

As a means of assuring that MWT's standard FETs are immune to this degradation phenomenon, a high temperature, operational life test in the presence of hydrogen was devised and completed. This paper describes the test completed and its results.

TEST DESCRIPTION

To perform the test, a standard microwave amplifier housing fabricated from aluminum was altered so that two 1/8" stainless steel tubing fittings could be connected to the housing. A schematic drawing of the housing is shown below.



For the phase 1 test, the amplifier housing contained four standard balanced 6-18 GHz gain modules. Each gain module contained two FETs from the same wafer. Devices from four different wafers were tested. All of the devices utilized for the test were MWT-2 FETs. The modules were DC characterized and RF evaluated and then inserted into the amplifier housing. The DC connections were made so that each module was under DC bias throughout the test. The lid was clamped on the amplifier and the forming gas (15% hydrogen) turned on. The flow rate was set at approximately 400 cm^3/min. The amplifier housing was placed on a hot plate with a surface temperature of 130°C. The temperature is limited by the characteristics of the casing feed-throughs. It is to be noted that if the DC dissipation in the FETs is taken into account with the applied surface temperature, that the estimated FET channel temperatures were in the range of 170°C to over 200°C. The test was run for a total of two weeks. The total DC current for the four modules was monitored throughout the test. The individual modules were characterized for both DC and RF performance prior to and subsequent to the high temperature life test. Table 1 summarizes the data taken before and after the high temperature, operational life test.

TABLE 1 ELECTRICAL DATA

Module	**Device**	**Wafer**		**DC***	**DC**	**6 GHz**	**Data**	**18 GHz**	**Data**	**Tch**
I.D.	**Type**	**I.D.**				**Gain**	**Power**	**Gain**	**Power**	**est.**
				(V)	**(mA)**	**(dB)**	**(dBm)**	**(dB)**	**(dBm)**	**(oC)**
E2121-1	MWT-2	2194	pre-	8	283	5.4	26.0	5.5	25.8	204
			post-	8	299	5.4	26.1	5.2	25.1	
E2173-1	MWT-2	2054	pre-	8	219	6.2	26.1	5.3	27.0	187
			post-	8	227	6.3	26.4	6.1	26.1	
E2180-4	MWT-2	2271	pre-	8	296	5.6	26.0	6.1	26.4	207
			post-	8	287	5.4	26.0	6.1	26.0	
E2302-1	MWT-2	2265	pre-	8	160	6.7	25.8	6.3	25.1	172
			post-	8	160	6.7	25.8	6.3	24.5	
				* Device Vds = 6.5 volts						

For the phase 2 test, two sets of three modules each were assembled and characterized. One set of modules (2 - 8 GHz gain blocks) used the MWT-1 FETs in a negative feedback dual stage configuration. The other set of modules (2 - 6 GHz gain blocks) used the MWT-9 FETs in a balanced configuration of two devices per module. Each of the modules were assembled using devices from different wafers. After DC and RF characterization, all six modules were installed in the amplifier housing described above. A two week operating life test was completed using the same conditions described above for the phase 1 test. After the operating life test all the modules were removed from the amplifier housing and recharacterized. The data are summarized in Table 2.

TABLE 2 ELECTRICAL DATA

Module	Device	Wafer		DC*	DC	2 GHz	Data	8 GHZ	Data	Tch
I.D.	Type	I.D.				Gain	N.F.	Gain	N.F.	est.
				(V)	(mA)	(dB)	(dB)	(dB)	(dB)	(oC)
E2346-2	MWT-1	2356	pre-	8	176	18.7	4.0	18.8	2.4	165
			post-	8	174	18.8	3.9	18.9	2.3	
E2257-5	MWT-1	2006	pre-	8	167	16.2	3.9	16.4	2.7	162
			post-	8	168	16.7	3.8	16.8	2.6	
E2342-3	MWT-1	2225	pre-	8	166	18.4	4.1	18.7	3.4	161
			post-	8	166	18.6	4.0	18.9	3.4	
Module	**Device**	**Wafer**		**DC***	**DC**	**2 GHz**	**Data**	**6 GHZ**	**Data**	**Tch**
I.D.	**Type**	**I.D.**				**Gain**	**N.F.**	**Gain**	**N.F.**	**est.**
				(V)	**(mA)**	**(dB)**	**(dB)**	**(dB)**	**(dB)**	**(oC)**
E2183-3	MWT-9	1820	pre-	8	272	12.3	3.9	12.7	3.3	182
			post-	8	274	12.2	4.1	12.7	3.4	
E2205-3	MWT-9	2282	pre-	8	252	11.6	5.1	12.1	4	180
			post-	8	251	11.6	5.2	11.7	4.1	
E2225-3	MWT-9	2089	pre-	8	271	12.3	4.4	12.6	3.4	182
			post-	8	270	12.3	4.4	12.7	3.5	
		* Device Vds varied for different modules between 4.7 and 5.0 volts								

CONCLUSIONS

The phase 1 data in Table 1 demonstrate that the MWT-2 devices are not sensitive to the presence of hydrogen at elevated temperatures. The DC current into the modules before and after varied by only a few per cent in some cases to none at all in one case. The 6 GHz RF data showed only small changes in both gain and output power between the two measurements taken before and after. Although the 18 GHz data did show some changes in output power, the gain changes were minimal and believed to be primarily associated with measurement repeatability from different test apparatus. It is important to note that in three of the four modules tested, the channel temperatures for the FETs exceeded the recommended maximum of 175°C. The estimated channel temperature is provided in the last column of Table 1.

The phase 2 data in Table 2 demonstrate that both the MWT-1 and MWT-9 devices are not sensitive to the presence of hydrogen at elevated temperatures. The DC current into the modules and the RF evaluation data varied minimally between pre-burn-in and post-burn-in characterizations. The gain changes were less than 0.5 dB and the noise figure changes were less than 0.2 dB. It is to be noted that both layout configurations, T-gate and interdigitated, were used for the test.

The results of the high temperature, operational life test indicate that the metallization structure of the MWT FETs which does not contain platinum or palladium is insensitive to the presence of significant amounts of hydrogen in the housing at elevated case temperatures.

REFERENCES

[1] P.W. Schuessler, "The Effects of Hydrogen on Device Reliability," Hybrid Circuit Technology, pp. 19-26, January 1991.
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[4] S. Kayali, "Hydrogen Effects on GaAs Device Reliability," 1996 GaAs MANTECH Symposium Proceedings, pp. 80-83, 1996.