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1200V SiC MOSFET (Infineon, Wolfspeed, and Rohm) TECHNOLOGY BENCHMARK REPORT

Aug 2018. LTEC Corporation released the technology benchmark report of the latest 1200V Si C MOSFET of Infineon, Wlfspeed and Rohm. It includes the following contents; Technique for realizing high reliability operation at high temperature, Structural analysis result, Evaluation of the figure of merit from the electric property evaluation result, Cost analysis such as chip cost and wafer cost, and so on.

Report overview

The following data is insufficient in the SiC power transistor data sheet, and this report complements such insufficient parts using the correlation between physical analysis and electrical characteristics.

1. Off-drain leakage current voltage and temperature dependency
2. Threshold voltage DIBL (Drain Induced Barrier Lowering), drain voltage dependency
3. Short circuit (short circuit, SC) capacity
4. The thermal impedance of short pulse time (1 us to 100 us)

Analysis summary

- The SiC MOSFET realizes about 1/20 in switching energy for the Si - IGBT used for reference. The simulated maximum switching frequency are 16 kHz for Si-IGBT and 200-400 kHz for SiC MOSFET.
- Despite the high threshold V_{th} , the company C SiC has the lowest RON_{xA} at high temperature ($644 \text{ m}\Omega \cdot \text{mm}^2$). It is nearly twice as $1168 \text{ m}\Omega \text{mm}^2$ against the company A SiC.
- It is predicted that the on-resistance (RON_{xA}) trend per unit area will continue the reduction rate of 30% / 3 years.
- We estimate wafer cost and average selling price (ASP) of those three companies in this report.

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2.5 Table 4: Current status of SiC devices and module manufacturers (as of April 2018)

No.	Company	LTEC Report?	Epi Wafer	Device Chip	Module	Comments
1	WOLFSPEED (CREE)	Yes				
2	ROHM	Yes				relatively 8).
3	MITSUBISHI Electric	Yes				
4	Fuji Electric	Yes				
5	Hitachi					
6	Infineon	Yes				
7	STMicro	Yes				power card.
8	MicroSemi	Yes				
9	IXYS→ LITTELFUSE	Yes				
10	General Electric (GE)					odule,
11	United SiC Corp	Yes				
12	X-Fab					
13	Denso					
14	Toyota					
15	Monolith (US)			✓		Using SiC Foundry (X-Fab)

Table.1 FOM outline and device cost and sales price

			SiC			Si
Summary of Performance FOMs		Units	A	B	C	D IGBTs
FOM	Specific Effective ON Resistance, RONxA @ Tj=Tjmax	mΩ·mm ²	1168	670	644	2600
	Specific Intrinsic ON Resistance, RONxAA @ Tj=Tjmax	mΩ·mm ²				
	Qg x RON @ Tj=Tjmax	nC·Ω				
	Ciss x RON @ Tj=Tjmax	pF·Ω				
	Crss x RON @ Tj=Tjmax	pF·Ω				
	Coss x RON @ Tj=Tjmax	pF·Ω				
	Turn-off Switching Energy, Eoff x RON @ Tj=Tjmax	mJ·mΩ				
	Turn-on Switching Energy, Eon x RON @ Tj=Tjmax	mJ·mΩ				
Maximum Switching Frequency, fmax	kHz					
Cost & Price	Average Selling Price, ASP (Retailer)	\$/unit				
	ASP per Ampere (@ 100°C)	\$/A				
	ASPxRON	\$/Ω				
	Estimated Manufacturing Die Cost	\$/unit				
	Processed Wafer Cost (Estimated)	\$/wafer				

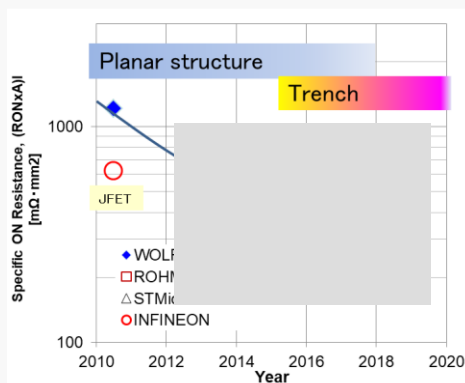


Fig. 3.4: Trend of on-resistance (RONxA) performance index (FOM) per area

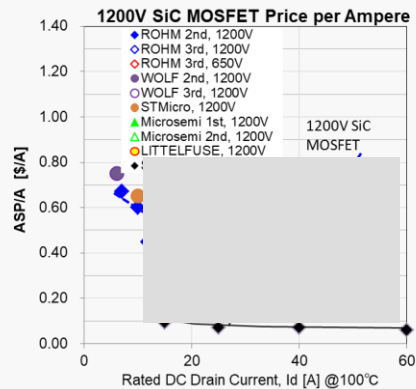


Fig. 4.3: Average selling price per ampere (ASP / A)

※レポートデータ抜粋

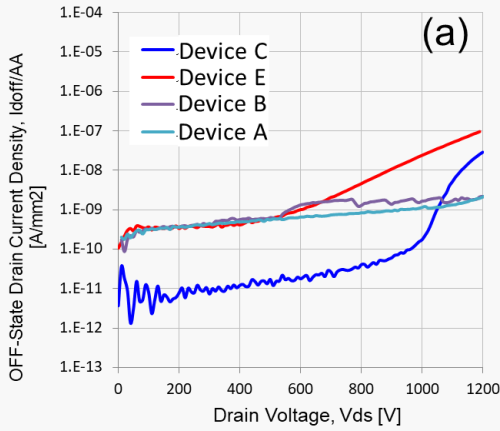


Fig. 5.14: Comparison of drain leakage current

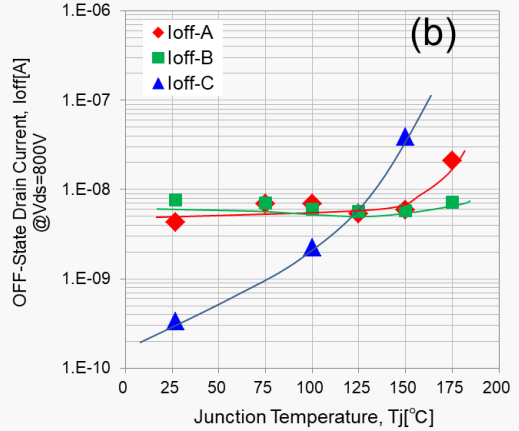
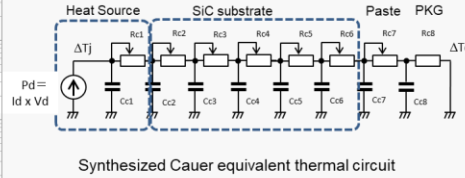
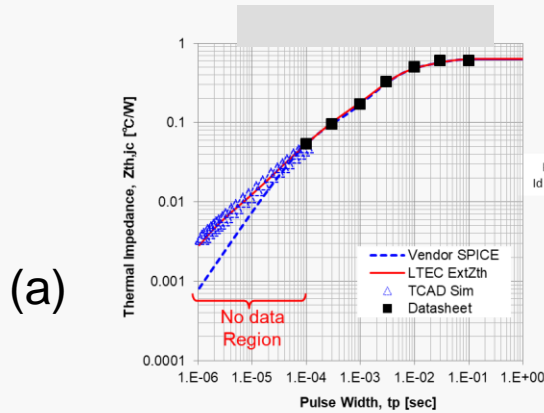


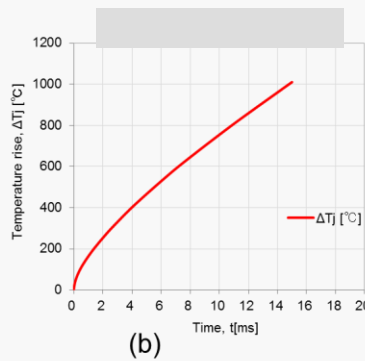
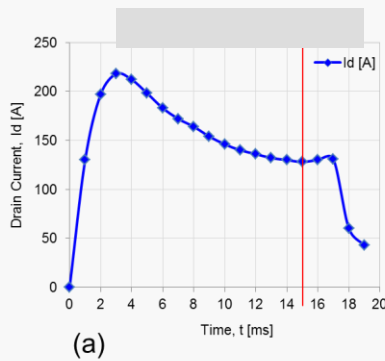
Fig. 5.15: Drain current temperature dependence at off mode: I_{off} ($V_{gs} = 0$ V and $V_{ds} = 800$ V)



(a)

(b)

Fig. 5.30: (a) Thermal impedance Z_{th} vs. on-time pulse width (b) extracted equivalent heat circuit



(a)

(b)

Table 3: Summary of the estimated device temperature ΔT_j

		Datasheet Graph	Manufacturer Zth model	1D Model	Simulated
P_d	W		8.43×10^4		
t	μs		15		
Z_{th}	$^{\circ}C/W$	0.006※	0.003	0.0106	
ΔT_j	$^{\circ}C$	506	253	894	1033

※ Extrapolated from graph

Fig. 5.31: (a) Shorted drain current waveform at $V_{ds} = 580$ V and $V_{gs} = 19$ V (b) Die temperature at short circuit mode Table 3. The data summary of the device temperature calculated from this analysis (yellow)