LTEC IP Service

New Release

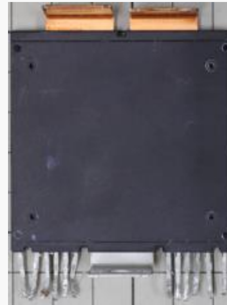
LTEC Corporation

Your most experienced partner in IP protection

SiC MOSFET(1200V)：ON Semiconductor(equipped in Kia EV6 GT) Power card Structure, Process analysis Reports.

Kia EV6 GT (From web information)

(https://www.kia.com/uk/new-cars/ev6-gt/#text_441302445)



Power card appearance

SiC MOSFET die

Report summary

The Kia EV6 GT was announced by Kia Motors, a subordinate of Hyundai Motors, in March 2021, and is high-performance model of the company's first BEV (battery electric vehicle) Kia.
The inverter that drives the rear motor of EV6(2022model) consists of two units. One inverter is for normal mode using Infineon Si-IGBT module, another inverter is added during high output mode using ON Semiconductor (OnSemi) SiC power cards.
This time, LTEC released two reports (1. Structure analysis report and 2. Process analysis report) of OnSemi SiC MOSFET power card equipped in this inverter.

Product specifications/features

Product number : NVVR26A120M1WSS 1200V SiC MOSFET Power card

Product release date: 2022

Analysis Contents/Overview of Results

1. Structure analysis Report (98 pages)

- A two-layer metal process is used to maximize transistor area.
- Cu ribbon is used for the source wire, and Ag sinter is used for die attach.
- The power module uses a DBC substrate, and the insulation layer is Al, N based.

2. Process analysis Report (42 pages)

- The on-resistance per unit area (RONxA 465mΩ･mm^2) is equivalent to other companies' 2nd to 3rd generation SiC process.
- The thickness of the N-epi (drift) layer and doping concentration are extracted and correlated with the measured breakdown voltage BVdss.
- Estimating the manufacturing process flow and the number of photo/masking steps.

Please contact us for report pricing.

LTEC IP Service
LTEC Corporation US Representative Office www.ltec-biz.com/en/
No.203 2880 Zanker Road San Jose, CA 95034
Phone: (408) 489-1994
Contact2@ltecusa.com

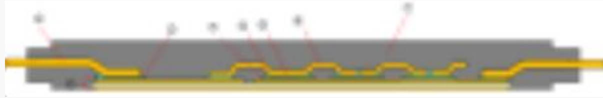
Report No : 23G-0469-1,2
Release day : 2023.10.31

(1) Excerpt from structure analysis report

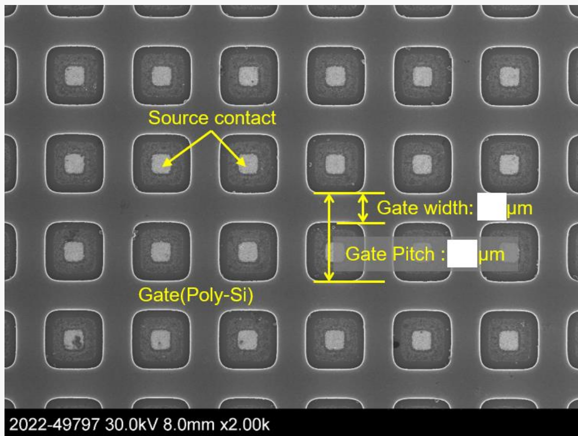
Content

Content		Page
1. Device Summary	・・・	3
1-1. Summary of analysis results	・・・	4
2. Module analysis		
2-1. Product appearance	・・・	9
2-2. Internal layout observation	・・・	13
2-3. The mounted die	・・・	17
2-4. Module cross-sectional observation	・・・	18
3. SiC MOSFET Structure analysis		
3-1. Plane structure analysis by Optical Microscope	・・・	43
3-2. Plane structure analysis by SEM	・・・	59
3-3. Cell array cross-sectional structure analysis	・・・	71
3-4. Cross-sectional structure analysis of MOSFET die outer periphery	・・・	77
3-5. Gate pad cross-sectional structure analysis	・・・	86
3-6. Gate wiring cross-sectional structure analysis	・・・	90
4. TEM structure analysis		
4-1. TEM analysis	・・・	94

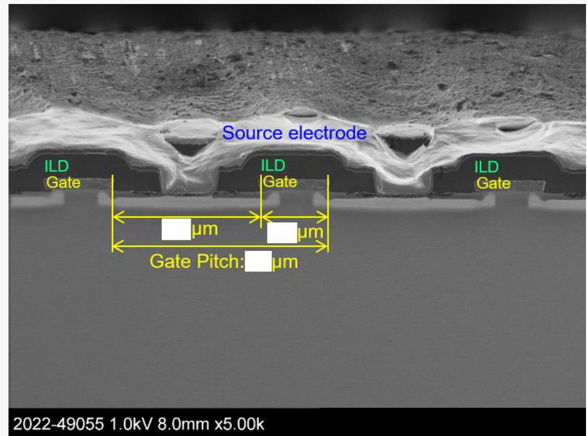
(1) Excerpt from structure analysis report



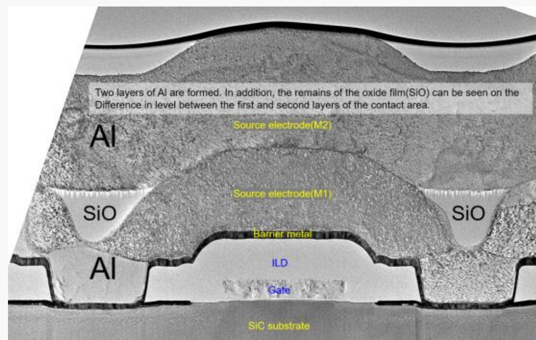
Number	Measurement points		Measurement	Material
1	Mold resin		–	[illegible]
2	Output terminal		–	–
2-1		Plating layer	[illegible]	[illegible]
2-2		Terminal	[illegible]	[illegible]
3	Solder		[illegible]	[illegible]
4	Cu ribbon		[illegible]	[illegible]
5	Solder		[illegible]	[illegible]
6	SiC-MOSFET		–	–
6-1		Protective film	[illegible]	[illegible]
6-2		Top electrode 3	[illegible]	[illegible]
6-3		Top electrode 2	[illegible]	[illegible]
6-4		Top electrode 1	[illegible]	[illegible]
6-5		Substrate	[illegible]	[illegible]
6-6		Back electrode-1	[illegible]	[illegible]
6-7		Back electrode-2	[illegible]	[illegible]
7	Die attach		[illegible]	[illegible]
8	DBC substrate		[illegible]	–
8-1		Upper electrode	[illegible]	[illegible]
8-2		Insulation layer	[illegible]	[illegible]
8-3		Bottom electrode	[illegible]	[illegible]



Plane cell array (Poly-Si layer)



Cell array cross-section (SEM)



Cell array cross-section (TEM)

Die outer periphery cross-section (SEM)

LTEC Corporation US Representative Office www.ltec-biz.com/en/
No.203 2880 Zanker Road San Jose, CA 95034
Phone: (408) 489-1994
Contact2@ltecusa.com

(2) Excerpt from process analysis report

Content | Page

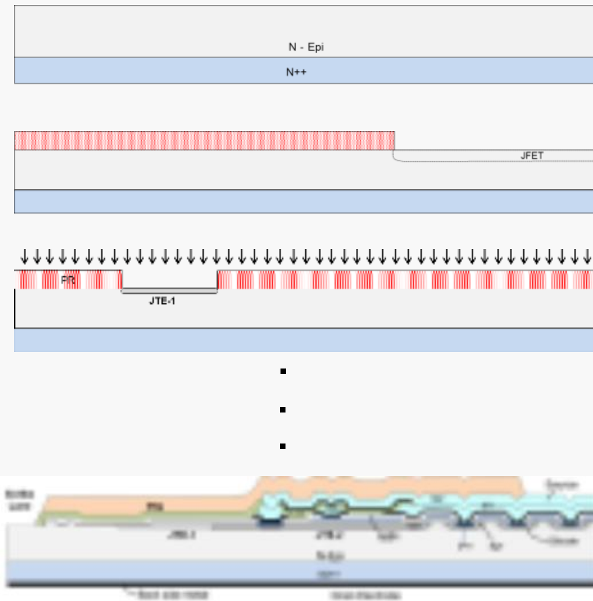
1		onsemi (equipped in KIA EV6 GT) power card SiC MOSFET: Summary of analysis results·······································	3
	1-1	Characteristics comparison between onsemi and other companies' SiC MOSFETs	4
	1-2	SiC MOSFET whole die ···	5
	1-3	Die edge ··	6
	1-4	Device structure: SiC MOSFET ··	7
		Transistor schematic cross-sectional view ···························	7
2		SiC MOSFET observation ···	8
	2-1	Cross-sectional and planar structure analysis by SEM ············	8-16
		Feature of transistor structure and process(1)—(9) ··············	8-16
	2-2	Details of self-alignment formation process of N+ and P well Diffusion to define the channel length Lch (estimate) ···············	17
3		onsemi SiC MOSFET NTH4L028N170M1 analysis results summary	18
		Table 3-1 Device structure : SiC MOSFET ····························	18
		Table 3-2 SiC MOSFET structure : Layers material/thickness	19
4		Manufacturing Process Flow···	20
	4-1	SiC MOSFET front-end wafer process flow (estimated) ············	20
	4-2	Cross-sectional schematic views of SiC MOSFET process sequence	21-25
5		Electrical characteristics evaluation ·····································	26
	5-1	onsemi 1200V SiC MOSFET NVVR26A120M1 Id-Vds characteristics	27
	5-2	Off-state drain current vs. drain voltage (Vds) and activation energy(Ea) with device Temperature as a parameter···············	28
	5-3	Off-state breakdown voltage BVdss characteristics ···············	29
	5-4	Gate leakage current Igss characteristics ···························	30
	5-5.	Comparison of leakage current between manufactures············	31
	5-6	Body diode characteristic ···	32
	5-7	Capacitances(Ciss, Coss、Crss)-Vds characteristics ············	33
	5-8	Device structure and electrical properties analysis: ON resistance	34-36
	5-9	N-epi layer impurity concentration analysis ························	37
	5-10	Device structure and electrical properties analysis:Breakdown voltage	38
6		Related references ··	39
7		Related references ··	39-42

LTEC Corporation US Representative Office www.ltec-biz.com/en/ Phone: (408) 489-1994
No.203 2880 Zanker Road San Jose, CA 95034 Contact2@ltecusa.com

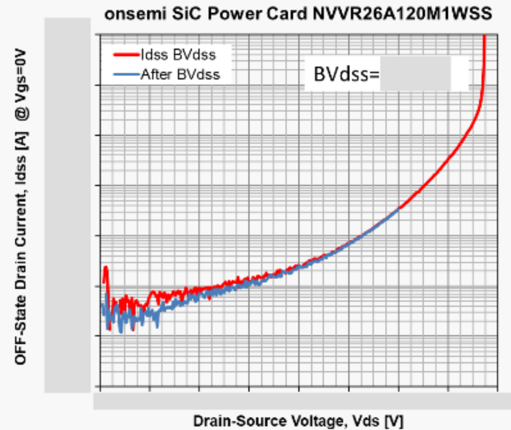
(2) Excerpt from process analysis report

Characteristics comparison between onsemi and other companies’ SiC MOSFETs

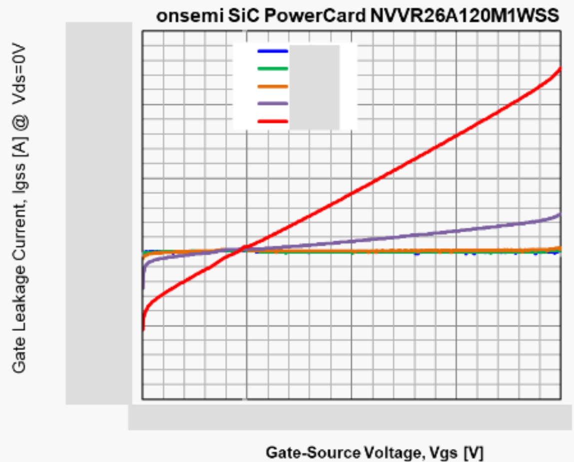
Maker	Part no.	Process generation	Manufacture	Die size mm x mm	Die size mm2	Vdss [V]	RON [mΩ]	Intrinsic RONxA [mΩ・mm²]
ROHM	SCT3080KL	3rd	2016	[illegible]	[illegible]	1200	80	[illegible]
ROHM	SCT4062KR	4th	2022	[illegible]	[illegible]	1200	62	[illegible]
WOLFSPEED	C3M0075120K	3rd	2017	[illegible]	[illegible]	1200	75	[illegible]
INFINEON	AIMW120R060M1H	1st+	2021	[illegible]	[illegible]	1200	60	[illegible]
Microsemi	MSC040SMA120B	2nd	2018	[illegible]	[illegible]	1200	40	[illegible]
GeneSiC	G3R75MT12K	3rd	2020	[illegible]	[illegible]	1200	75	[illegible]
onsemi	NVHL080N120SC1	1st SC1	2019	[illegible]	[illegible]	1200	80	[illegible]
onsemi	NVVR26A120M1WSS	M1	2023	[illegible]	[illegible]	1200	15.6	[illegible]
onsemi	NTH4L022N120M3S	M3S	2022	[illegible]	[illegible]	1200	22	[illegible]



Process flow (estimate)



Off-state breakdown voltage BVdss



Gate leakage current vs. Gate voltage

LTEC Corporation US Representative Office www.ltec-biz.com/en/ Phone: (408) 489-1994
No.203 2880 Zanker Road San Jose, CA 95034 Contact2@ltecusa.com