< New market survey report >

November, 2021

Power Module & Ceramic Substrate Report -2021-

The data augmented version of "Power Module Report -2020-"

Japan Marketing Survey Co., Ltd

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Features of this report and Focal points of survey

< Features of this report >

◆ Added the latest data on ceramic substrates to "Power Module Report 2020”

* Power module data is updated only for market size forecast data.

< Focal points of survey >

▼ Market Trends and manufacturer trends of IGBT /SiC power modules

- Classified by module capacity, by application, by insulating substrate material, by package type

▼ The updated comparison tables of product lineup situation of major 23 power module companies

- Classified by module capacity, by type of circuit, by PKG type, by PM / IPM

▼ Analysis of ceramic substrate market and corporate trends

- Market by ceramic material (Si3N4, AlN, Zr-Al2O3, Al2O3), by application
- Company case study of 10 major ceramic substrate manufacturers

Subjects of survey

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< Subjects of survey >

▼ Power module:

- All IGBT modules including IPM type,
- Any SiC power modules with 600V or greater, but excluding diode modules

▼ Ceramic substrate: Si_3N_4, AlN, Zr-Al_2O_3, Al_2O_3 substrates for Power devices

< Companies surveyed >

▼ Power module company

Infineon, Mitsubishi Electric, Fuji Electric, Semikron, Hitachi Power Semiconductor Device, ABB, Microchip, Vishay, Littelfuse, On Semiconductor, STMicroelectronics, Dynex, Vincotech, Starpower, Macmic, Powersem, Kyocera, Rohm, Sanken, Silvermicro, Silan, Wolfspeed, GE

▼ Ceramic substrate company

Denka, DOWA Metaltech, Tokuyama, Ferrotec Material Technologies, Hitachi Metals, KCC, Mitsubishi Materials, NGK Electronics Devices, Rogers, Toshiba Materials, Others

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Chapter 5 Market trends of Ceramic substrate for power devices

Sample of data -1-

Chapter 1

[Market overview of whole power module and SiC power module]

		2019	2022
Power module market	Volume (M units)	...	...
	Value (M USD)	4,990	...
	CAGR	...%	
Full SiC power module market	Volume (K units) *1	... (..%)	... (..%)
	Value (M USD) *1	... (..%)	... (..%)
	CAGR	...%	

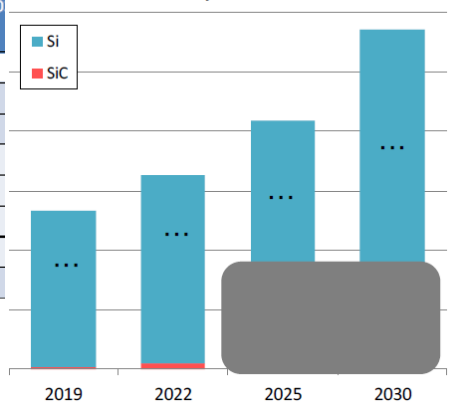
[Small capacity type power module market (volume base)]

		2019	Ratio	2022	Ratio	2025	Ratio	20
Volume market	Total (K units)	...,000	100.0%		100.0%		100.0%	
by PKG type	TM		..%		..%		..%	
	Case		..%		..%		..%	
by substrate	Resin		..%		..%		..%	
							..%	
							..%	
							..%	
by							..%	

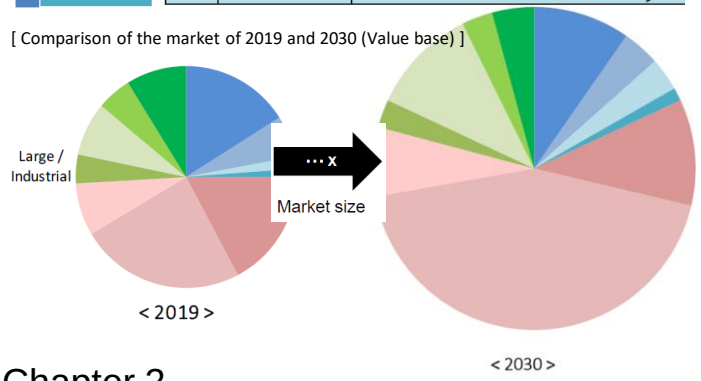
4.3 Trends of power module devices and the packaging for xEV drive

		2019	2022
Max power of motor for xEV	EV	30~450kW	
	PHEV		
	HEV		
PM for EV	Rated voltage value	✔ 650~750V	
Adoption rate of SiC module *1	EV		
	PHEV		
	HEV		
PM PKG type	Ratio of "Case : TM		
PKG material	Insulation circuit substrate		
	Bonding material		
Case type	Encapsulant		
	Circuit connection		
TM type	Ratio of "Single:Do sided cooling		
	Cooling type of dou sided module		

[Market size by SiC and Si base]



[Comparison of the market of 2019 and 2030 (Value base)]

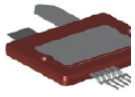


5. A table of market entry trend by module manufacturer, classified by capacity

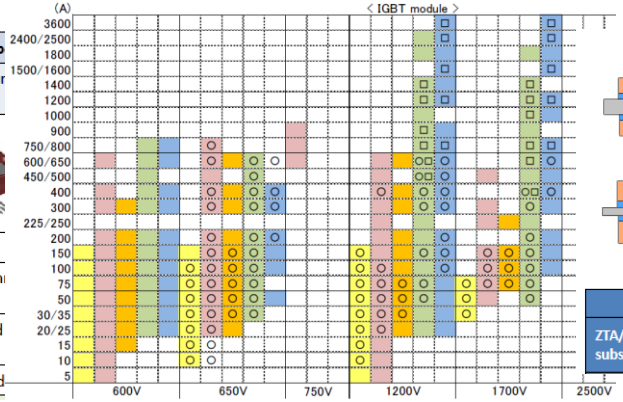
	Small capacity		Middle capacity		Large capacity	
	DIP/SIP-IPM			Module for xEV		High voltage
Fuji Electric						
Hitachi P.S.D						

Chapter 2

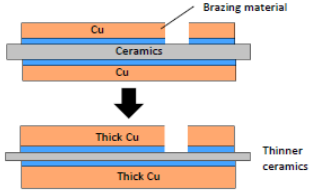
3.3.2 Product outline of major power modules

Module type		2 in 1 / TM typ
Product name /Manufacturer	HybridPACK DSC S1 / Infineon	Power card / Der
Image		
RV/RC	700V/400A	1200V/200A
External size	42.4x42x4.7(H)mm	50x58x5.2(H)m
Cooling side / Shape of Heat sink	Double-sided / Flat	Double-sided
Cooling type	Indirect liquid	Indirect liquid

5.2 Situation classified by capacity and circuit, of companies who entered the IGBT market



[Changes in the thickness of components of ceramic substrates and their effects]



Effect	• Improved heat dissipation thanks to the resistance • Increased current capacity
Side effect /Issue	• The substrates have ... • The increased thermal ...

The thinning of ceramics and the formation of thick Cu circ

[List of Ceramic substrate thickness by material]

	Thickness of ceramics	Thickness of Cu
ZTA/ZDA substrate	0.32	0.127 ~ 0.5

・ZTA/ZDA and Si3N4 substrates, ...

Sample of data -2-

Chapter 3

1.1.1 Classification by module capacity and application

		Application					
		Consumer	Industrial	Automotive	New energy	Railway	Total
Volume (K units)	Small						
	Middle	0					
	Large	0					
	Total						
Amount (K USD)	Small						
	Middle	0					
	Large	0					
	Total						
Average (USD/unit)							

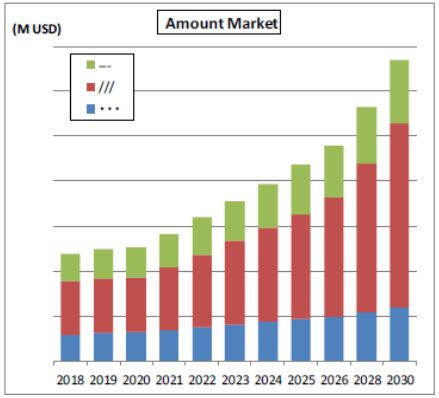
1.2.4 Classification by module capacity and application

	Module capacity	Application					Total (K units)	
		Consumer	Industrial	Automotive	New energy	Railway		
Infineon Technologies	Small					0		
	Middle	0				0		
	Large	0						
Mitsubishi Electric	Small					0		
	Middle	0				0		

1.3.3 Classification by module capacity and application

		2018	2019	2020	2021
Small	Consumer				
	Industrial				
	Automotive				
	New energy				
	Railway	0	0	0	
Middle	Consumer	0	0	0	
	Industrial				
	Automotive				
	New energy				
	Railway	0	0	0	
Large	Consumer	0	0	0	
	Industrial	229			
	Automotive				

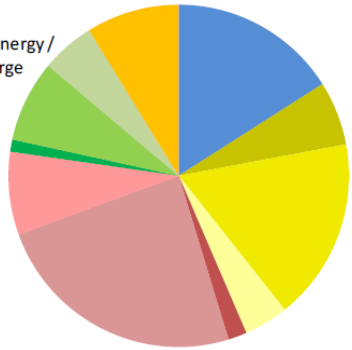
[Market forecast of whole power module by module capacity (volume and value bases)]

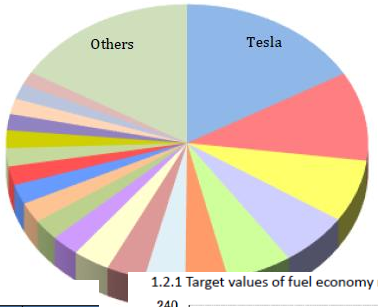


1.2.7 Classification by insulating substrate material and module capacity

	Insulation material	Module capacity			(Sub) Total (K units)	
		Small	Middle	Large		
Infineon Technologies	Resin			0		
	Al_2O_3					
	Si_3N_4	0				
	AlN	0				
Mitsubishi Electric	Resin					
	Al_2O_3					
	Si_3N_4					
	AlN					
	Resin			0		
	Al_2O_3					
	Si_3N_4					

[Market ratio of power module by module capacity (primary) and application (secondary) in 2019]

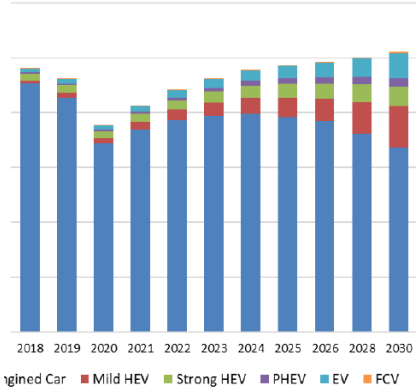




[Worldwide sales volume and market share of EV/PHEV by OEM in 2019]

Chapter 4

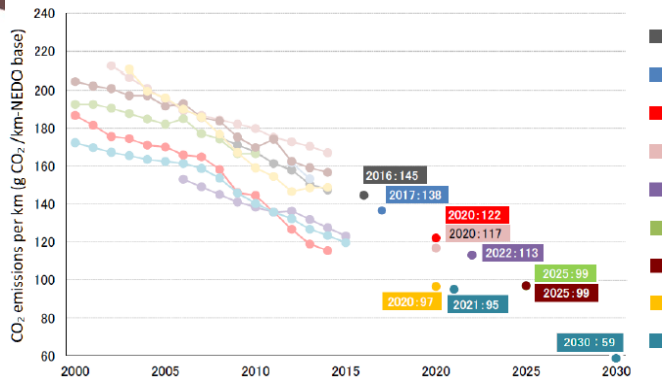
< Total automotive market >



1.1.2 Comparison of power train by type

		MHEV	HEV	PHEV	EV
Having an engine				Yes	
Driving only by motor				Yes	
	Driving range			20~150km	
Capacity of the battery				7~20kWh	
Power generation *1	Engine driving			-/Yes	
	Other method			-	
Motor *2	Number of mounted unit			1~3	
	Max output *3			50~300kW	
	Torque *3			160~400N・m	

1.2.1 Target values of fuel economy regulations in each country



Sample of data -3-

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Chapter 5

[Comparison of characteristics of ceramics and metals by material]

		Al_2O_3	$Zr\text{-}Al_2O_3$	Si_3N_4
Thermal conductivity	W/m･K	20~30	24~27	80~130
Linear CTE	10^{-6}/K			
Bending strength	MPa			
Fracture toughness	MPa･$m^{1/2}$			
Dielectric strength	kV/mm			
Dielectric constant				

[Product lineup of by thickness of materials]

Si3N4	Cu							
Ceramic	0.1X	0.2	0.25	0.3	0.4	0.5	0.8	1.0
0.25								
0.32								
0.38								
0.5								

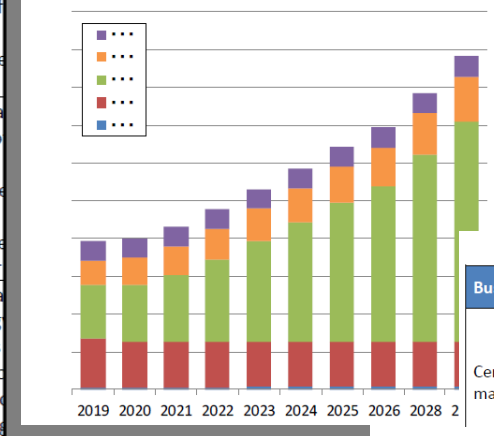
[Market entry situation by bonding method]

	Si_3N_4			AlN				Al_2O_3/$Zr\text{-}Al_2O_3$	
	AMB(Cu)	DCB	AMB(Al)	AMB(Cu)	DCB	AMB(Al)	MCB(Al)	AMB(Cu)	DCB
Denka	MP			MP		SP			
DOWA Metaltech									
Ferrotec Material Technologies									
Hitachi M									
Japan Fi									
Mitsubis									
NGK Ele									
Toshiba									

[Trends of metal ceramic substrates for power d

	Market trends
Al_2O_3 substrate	･The market size in 2020 was demand for industrial equipr ･The main applications are f demand for green. ･The market size in 2030 is e lowest compared to others.
$Zr\text{-}Al_2O_3$ substrate	･The market size in 2020 wa material. The main use is no market. ･Due to its strength characte increase in the future. ･The market size in 2030 is e second highest growth after
Si_3N_4 substrate	･The market size in 2020 wa it is also used for new energ ･Automotive drive inverters used by some major automo ･Compared to other ceramic Japanese circuit makers is tig

(M USD) < Value market >



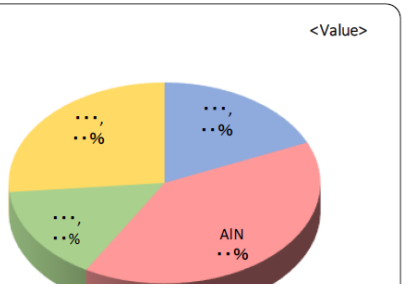
3.2.1 Overall market by ceramic substrate material

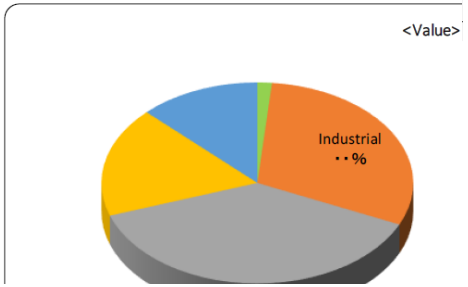
2) 2020

[Overall market]

	Volume (m^2)					Value (K USD)			
	Si3N4	AlN	Zr-Al2O3	Al2O3	Total	Si3N4	AlN	Zr-Al2O3	Al2O3
Rogers									
Denka			0	0				0	0
Mitsubishi Materials									
Ferrotec Mat. Tech.									
KCC									

[Market ratio of the substrates for power devices by ceramic material (left), by application (right) in 2020]





[Overall market size forecast by ceramic substrate material]

	2019	2020	2021	2022	2023	2024	2025
Al2O3							
Zr-Al2O3							
Si3N4							
AlN							
Total (m^2)							
Yearly change	-	%	%	%	%	%	%

[Production status by process of ceramic substrate for power devices]

Business by process		Metalized substrate	Plane substrate	Powder
Ceramic material	Si3N4	Yes	None	None
	AlN	Yes	None	None
	Zr-Al2O3	Yes	None	None

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