Félvezető alkatrészek járműipari fejlesztésekben

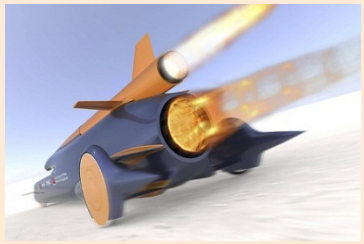
A Közlekedésautomatikai Tanszék
2012. március 19.

Előadó: Arany Zsolt, villamosmérnök, RSM (ROHM Semiconductor)

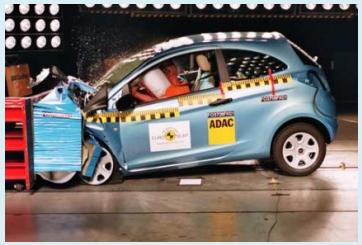
Dr. Szabó Géza

Fő célok

- gyorsaság



- energia

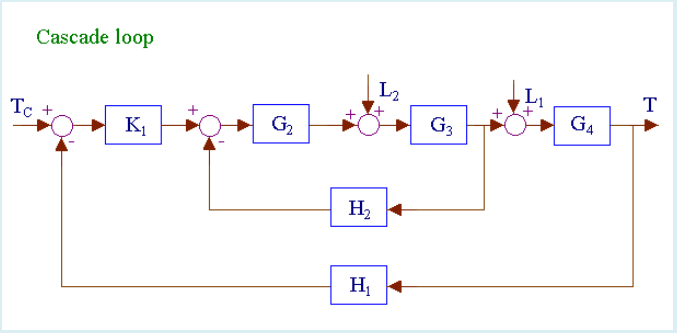


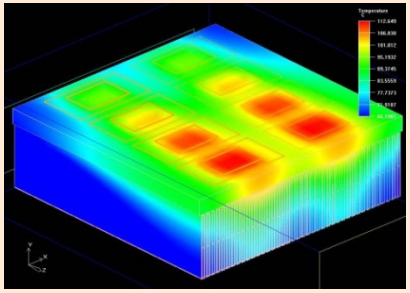
- biztonság

- kényelem

Fejlesztendő dolgok:

- szabályozás (control)



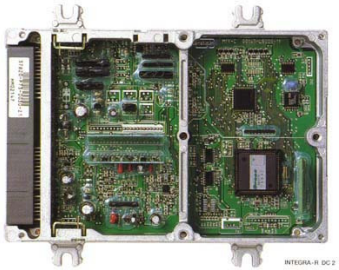


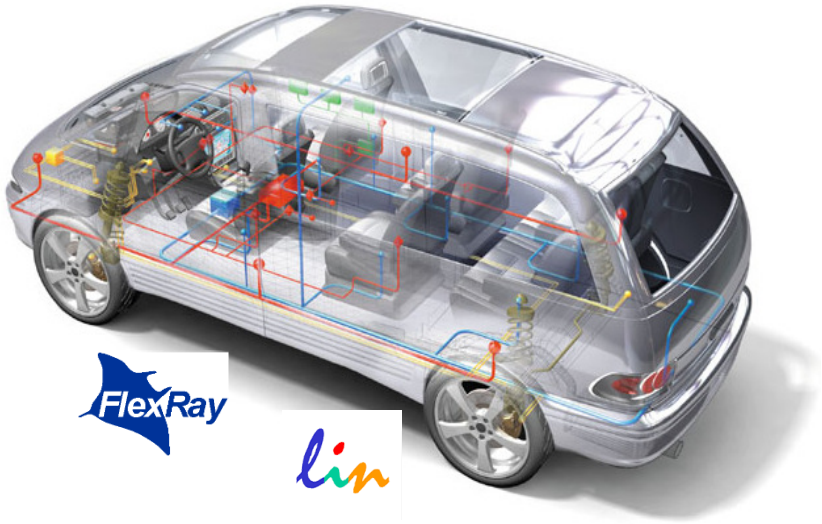
- teljesítmény (power)

- ember-gép interakció (infotainment)

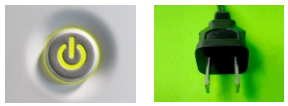
Fő elektromos részegységek a járműiparban:

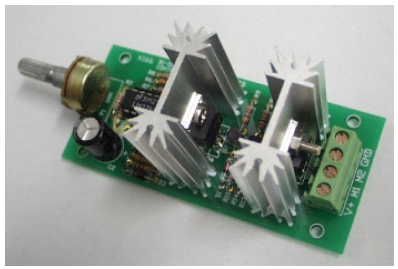
- vezérlő egység (ECU)
- hálózat (networking)
- teljesítmény menedzsment (power management)
- hajtás (power drive)
- kijelzők, lámpák, kapcsolók
- érzékelés

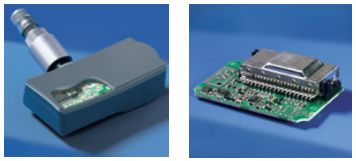




CAN SAFE-by-WIRE PLUS







Kapcsolat a célok és az alkatrészek között I.

Felhasznált félvezető eszközök (semiconductor devices):

- small signal diode / transistor
- DC/DC converter
- LDO
- LED / motor driver
- Power FET, IPM
- IGBT / SiC diode, MOSFET
- MCU
- transceiver
- sensor
- LED

Kapcsolódó részegységek a járműiparban:

- teljesítmény menedzsment
- hajtás (power drive)
- vezérlő egység (ECU)
- hálózat (networking)
- érzékelés
- kijelzők, lámpák, kapcsolók

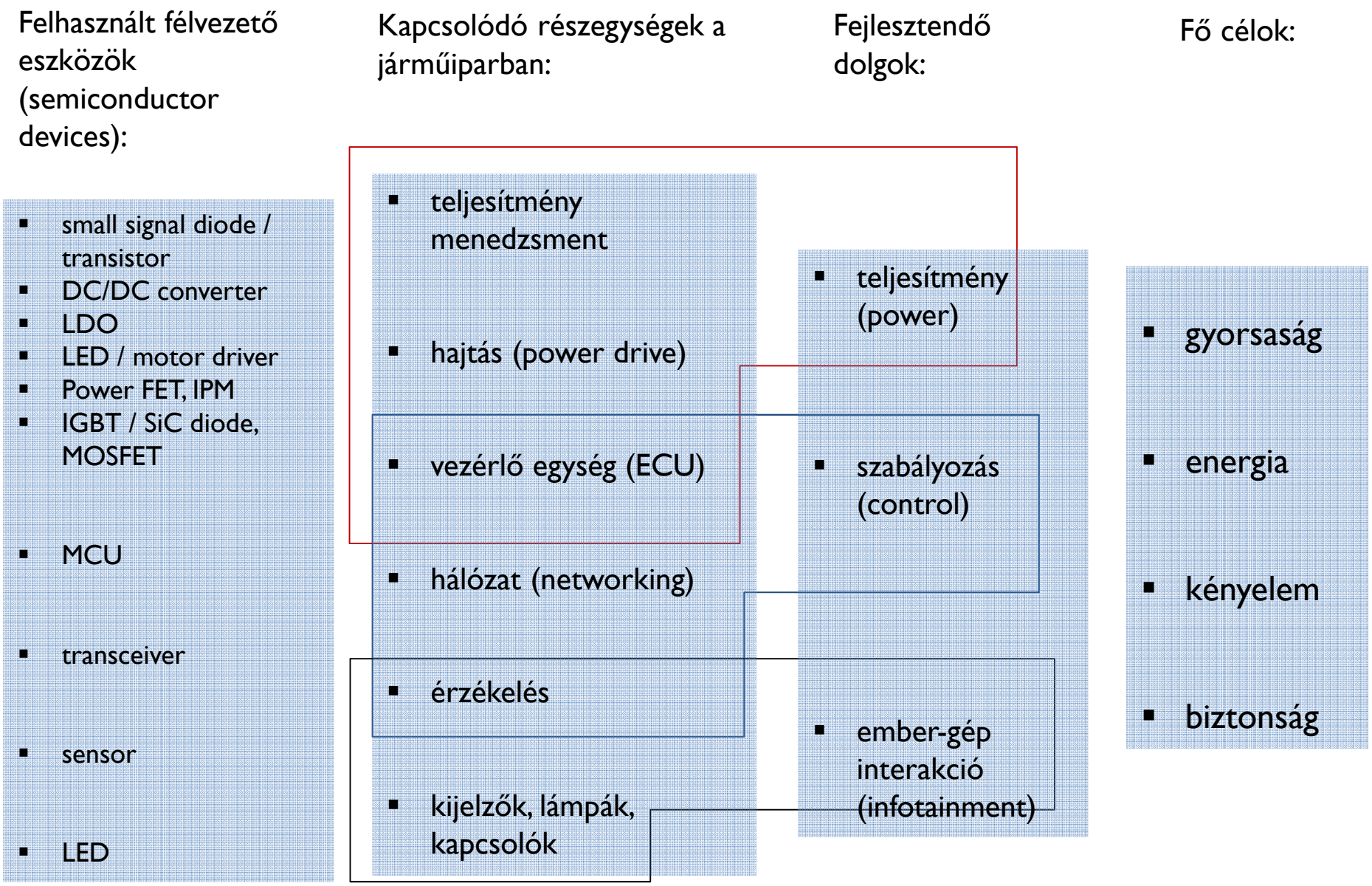
Fejlesztendő dolgok:

- teljesítmény (power)
- szabályozás (control)
- ember-gép interakció (infotainment)

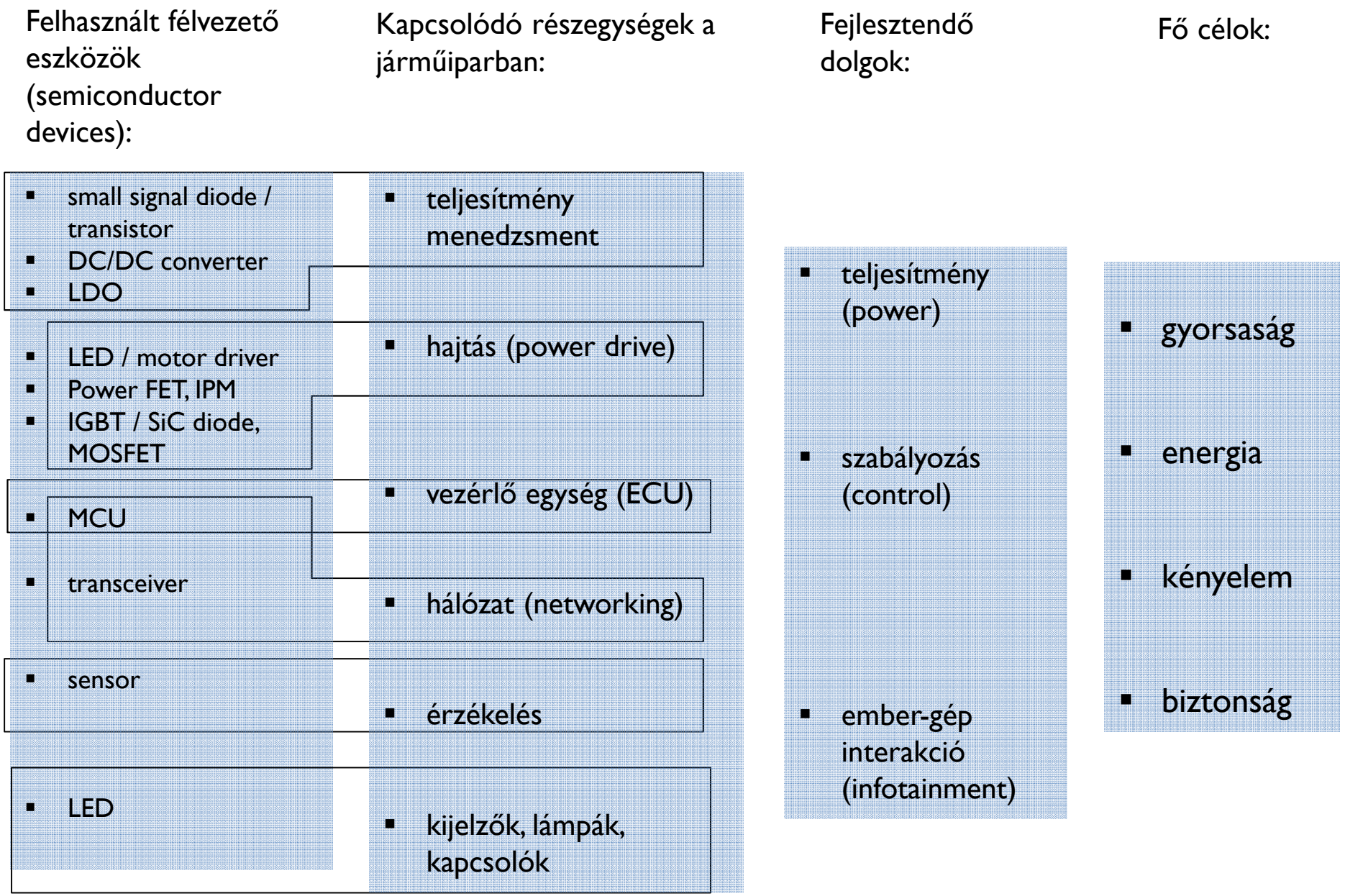
Fő célok:

- gyorsaság
- energia
- kényelem
- biztonság

Kapcsolat a célok és az alkatrészek között II.

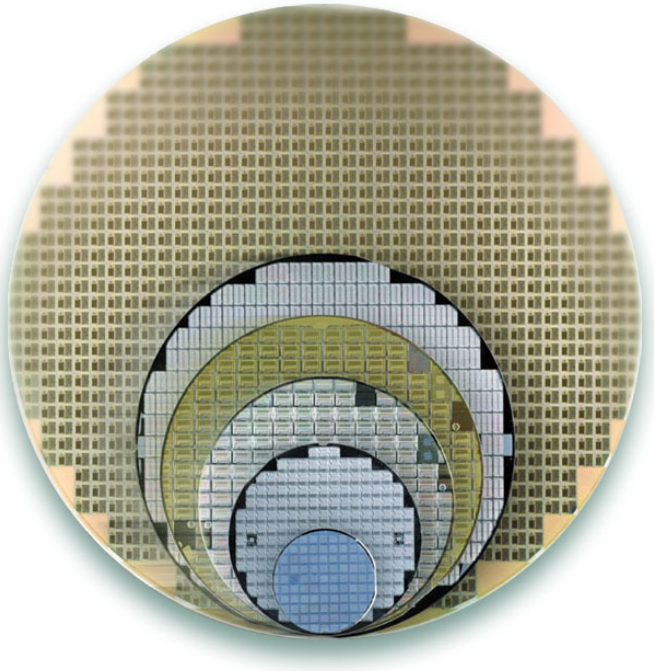


Kapcsolat a célok és az alkatrészek között III.



First Approach to Semiconductors

- What is a semiconductor?
- Diode, transistor, IC
- Production Technology
- Packages
- Packing

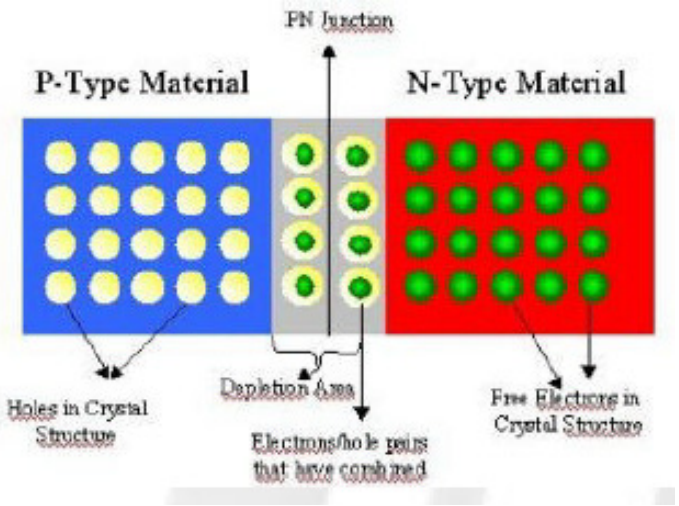


LDO = low dropout regulator, DC/DC converter = switching power regulator, MCU = microcontroller unit

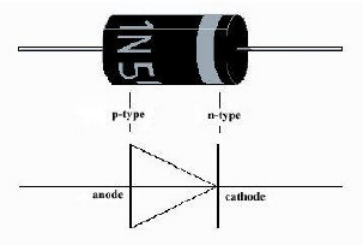
IGBT = Insulated gate bipolar transistor, SiC = silicon carbide, MOSFET = metal oxide semiconductor field effect transistor

What is a semiconductor?

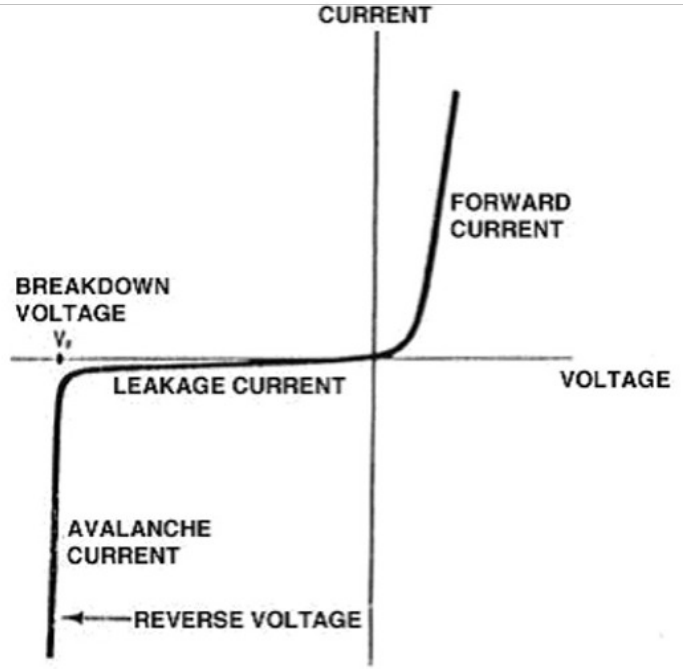
- solid-state material
- electrical conductivity can be controlled by orders of magnitude by adding very small amounts of alien elements known as dopants
- electrical conductivity can be controlled not only by negatively charged electrons, but also by positively charged holes



Diode

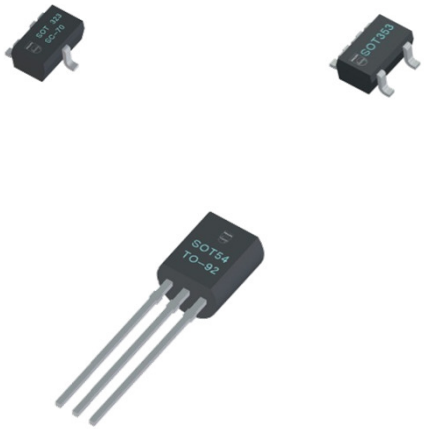


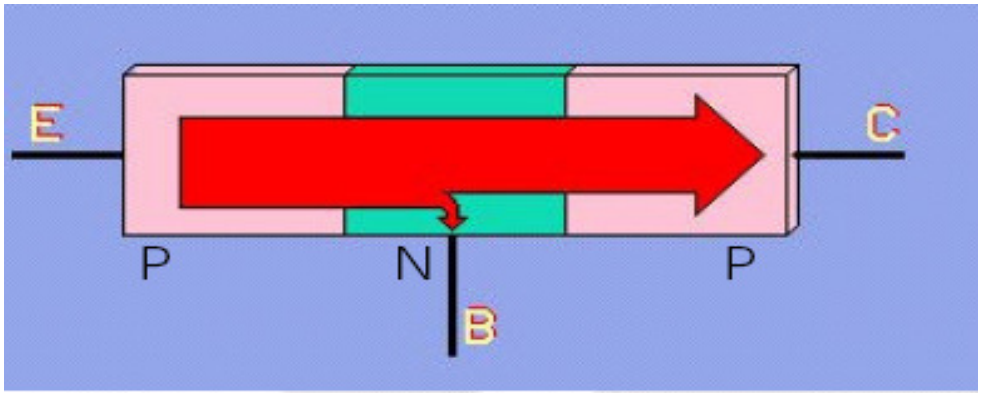
two-terminal semiconductor device which displays strongly rectifying current-voltage characteristics (large current flows under forward voltage bias while almost no current flows under the reverse voltage bias)

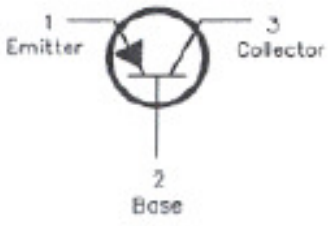


Transistor

three-terminal semiconductor device in which input signal (voltage or current on terminal B depending on the type of transistor) controls output current between terminal E and C

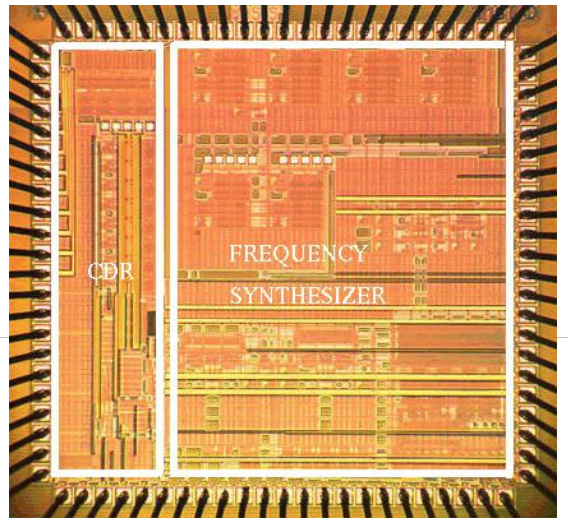






IC (Integrated Circuit)

entire electronic circuit built onto the single piece of a solid substrate and enclosed in a small package;

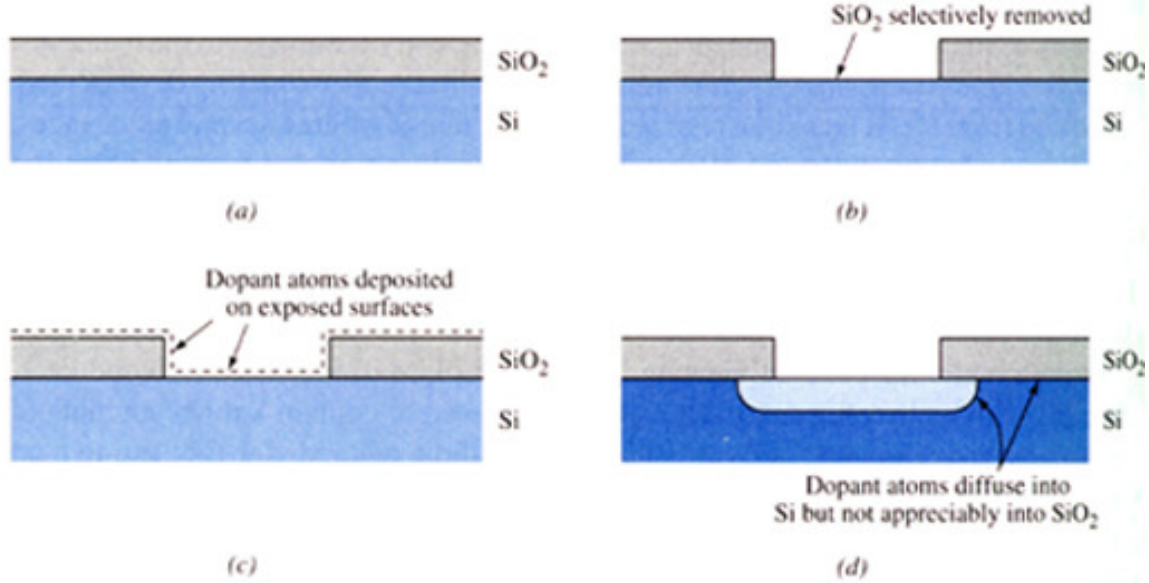


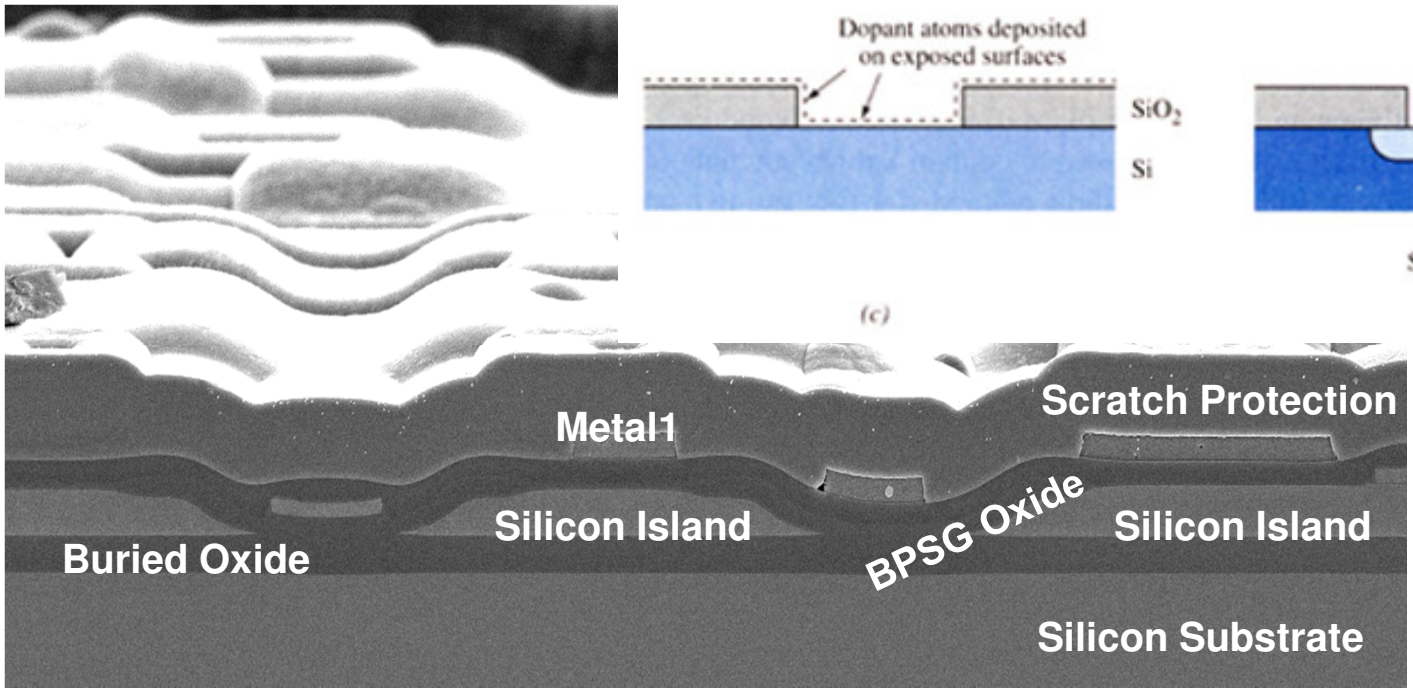
package is equipped with leads needed to electrically integrate IC with a larger electronic system;

the most common integrated circuits such as microprocessors, memories, etc., are all monolithic

Manufacturing Technology Phase1.

Diffusion = *Chip production by lithography*

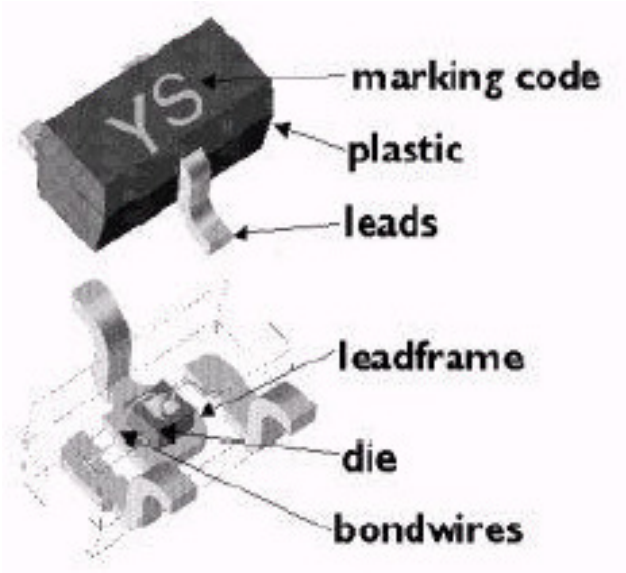


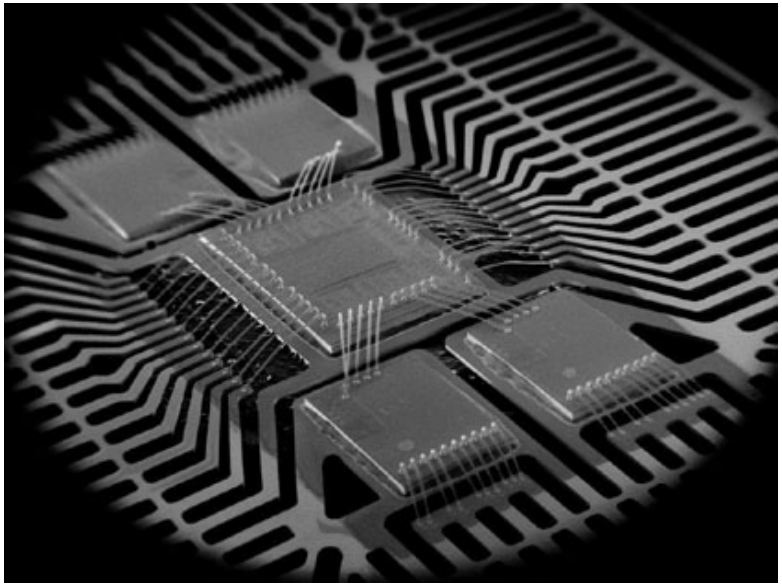


Manufacturing Technology Phase 2.

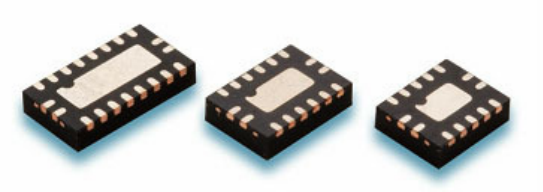
Assembly = *Packaging*

Putting the die (chip) on the leadframe, bonding its connections to the leads, moulding it around





Packages

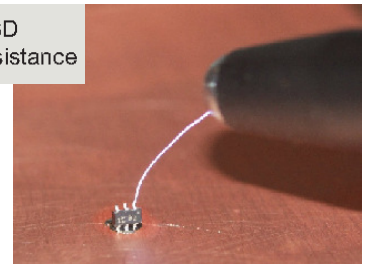


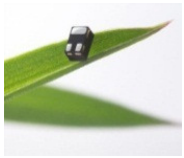
- Package miniaturization
  - –While increased functionality per square millimeter addresses the needs of system-on-chip solutions, multimarket semiconductors benefit more from package miniaturization
- Power-efficient solutions
  - –Increased demand for power and current handling capability
- Industry-standard packaging compatibility
  - –Continuing to push SMD and lead-frame solutions
  - –Applying innovative options (flip-chip, wafer-scale packages, bare die)
- Environmentally responsible packages
  - –Lead-free (zero Pb content) and green plastics

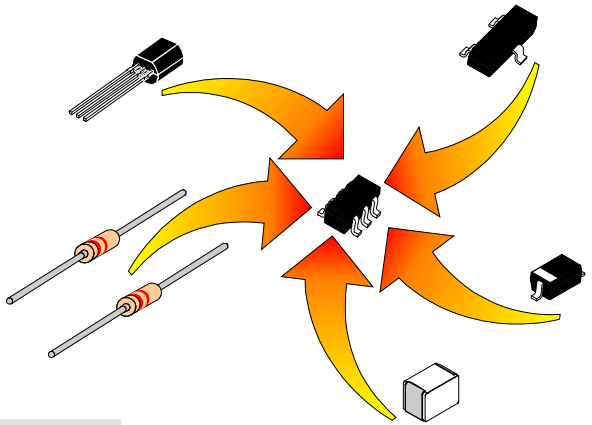
A félvezető alkatrészek a járműipar szempontjából fontos fejlesztendő tulajdonságai

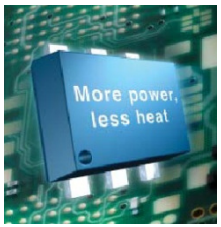
- Compliance to standards
- ESD
- Content
- Size
- Integration
- Voltage level
- Output current
- Power consumption, quiescent current
- Temperature range (-40-125Cgrad)
- Power dissipation

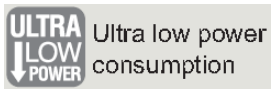
AEC-Q100 **CAN** FlexRay lin SAFE-by-WIRE PLUS

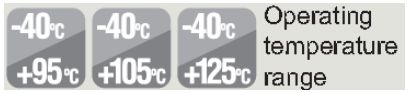


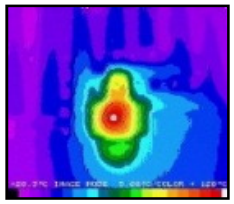


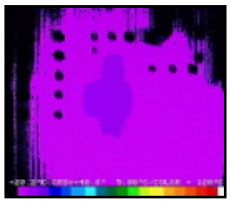






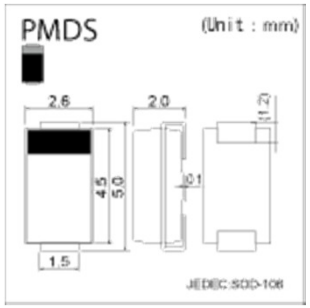






AEC = Automotive Electronics Council Q100 standard, ESD = Electrostatic discharge

2 typical examples for small signal diode and transistor used in automotive

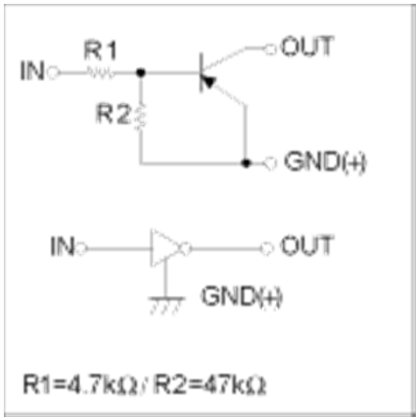


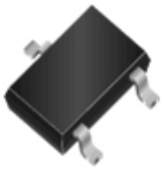
RB160L-40TE25

Absolute maximum ratings (Ta=25ºC)		
Rated parameters	Standard value	Conditions
Repetitive peak reverse voltage V_{RM}(V)	40	
Reverse voltage(DC) V_R(V)	40	
Average rectified forward current I_O(A)	1	
Forward current surge peak I_{FSM}(A)	70	60Hz/1cyc
Junction temperature Tj(°C)	150	
Storage temperature Tstg(°C)	-40 to +150	

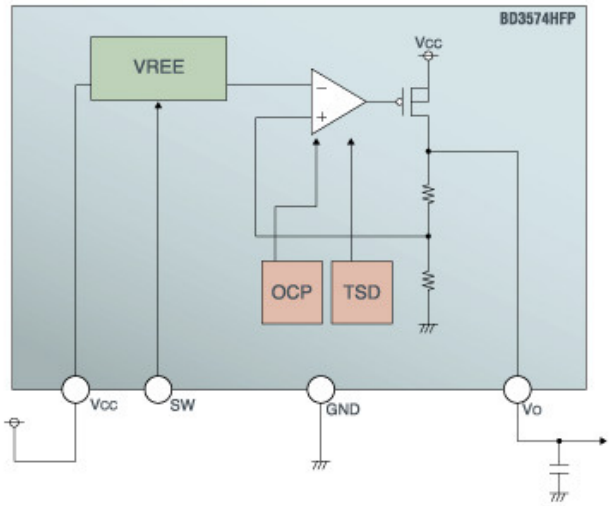
DTA143ZUA

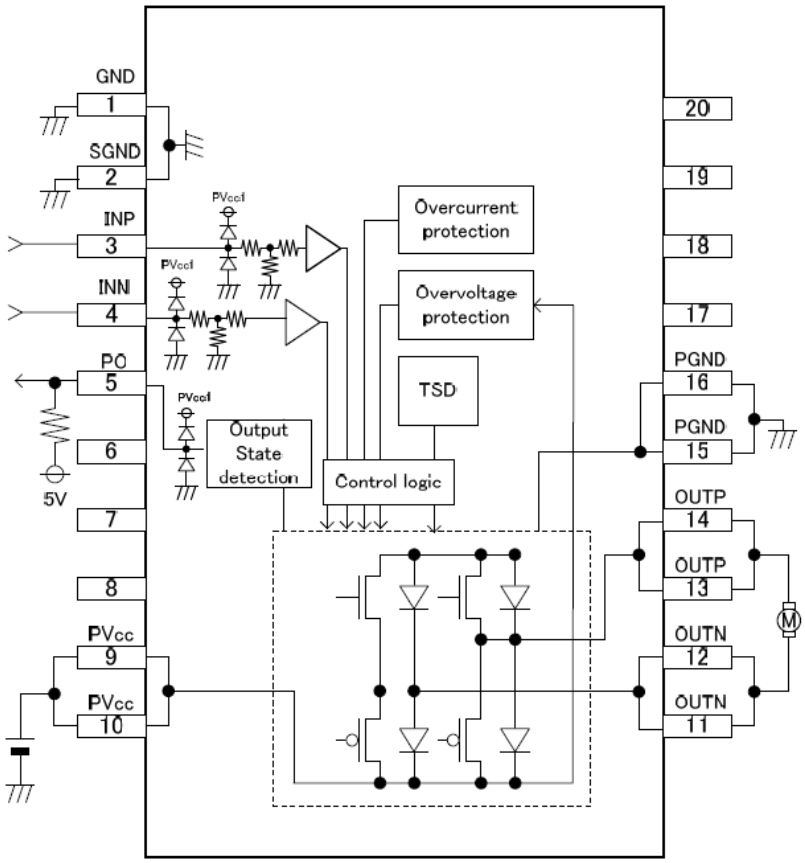
Absolute maximum ratings (Ta=25ºC)		
Rated parameters	Standard value	Conditions
Supply voltage V_{CC}(V)	-50	
Input voltage V_{IN}(V)	-30 to 5	
Collector current I_C(A)	-0.1	Characteristics of built-in transistor
Output current I_O(A)	-0.1	
Power dissipation P_D(W)	0.2	Each terminal mounted on a recommended land pattern
Junction temperature Tj(°C)	150	
Storage temperature Tstg(°C)	-55 to 150	





Typical LDO and motor driver in Automotive





Built-in thermal shut-down circuit

Built-in over voltage protection circuit

Built-in over current protection circuit

Ceramic capacitor available

-40℃ +95℃ -40℃ +105℃ -40℃ +125℃ Operating temperature range

4kV 5kV 6kV 8kV ESD resistance

Reverse polarity protection

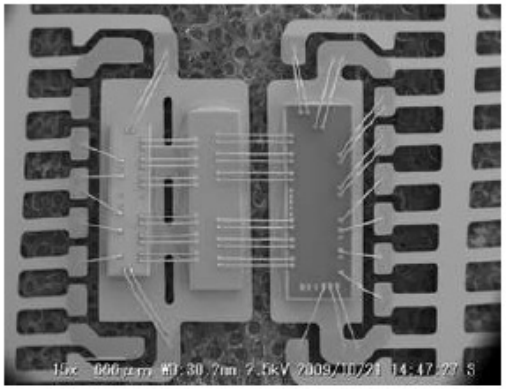
Iomax. 0.5A Iomax. 1.25A Maximum output current

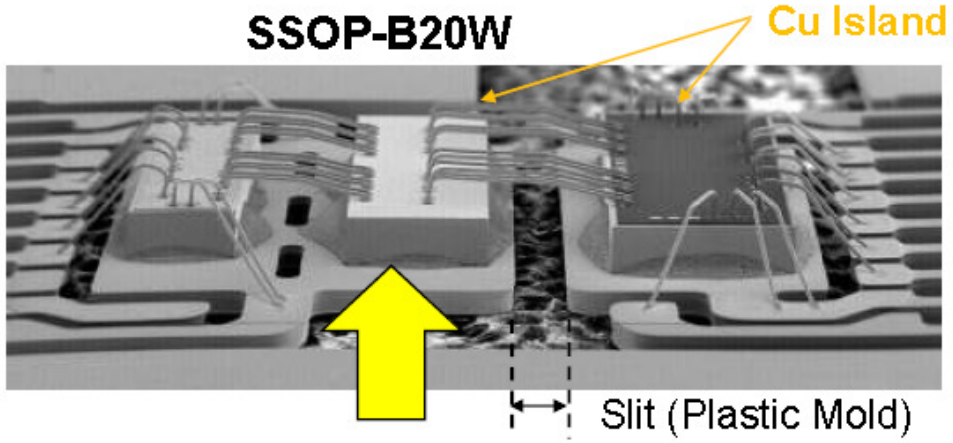
UV LO Built-in under voltage lock out circuit

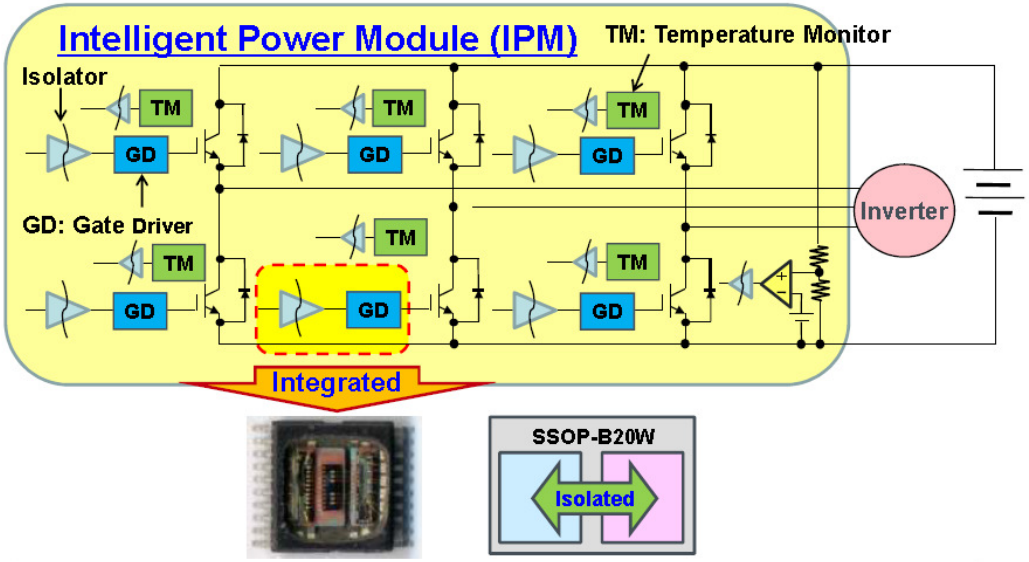
36V MAX. 50V MAX. Voltage resistance

LDO = low dropout regulator, DC/DC converter = switching power regulator

SiC-FET / IGBT Gate Driver



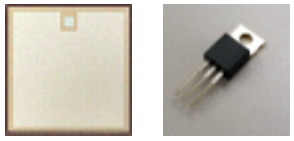


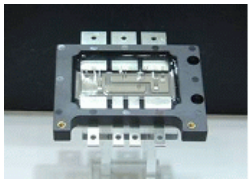


IGBT = Insulated gate bipolar transistor, SiC = silicon carbide, MOSFET = metal oxide semiconductor field effect transistor

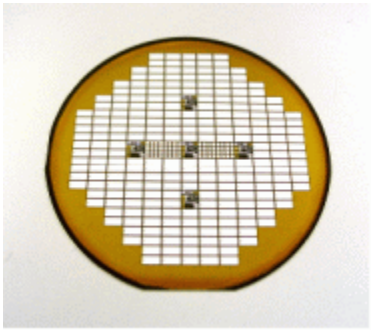
Expectation for SiC Power Device

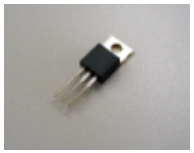
High breakdown field
(10 times higher than Si)
Wide band-gap
(3 times wider than Si)
High thermal conductivity
(3 times higher than Si)





SiC Power Devices



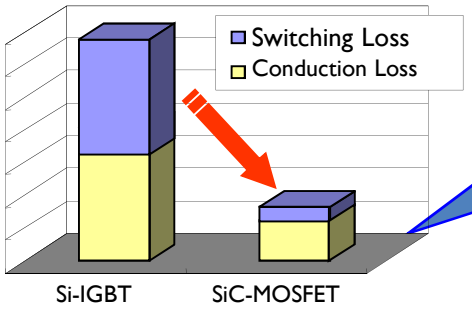


✓ **Lower Power Loss**

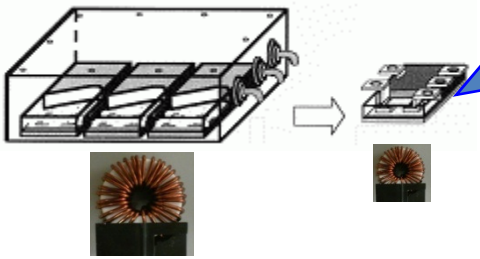
✓**High Temp. Operation**

Application

- Higher Efficiency (Lower Power Loss)
- Smaller Size in Modules, Cooling System, and Passive Components
- High Frequency Operation
- High Temp. Operation



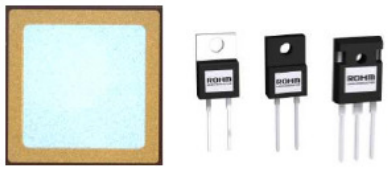
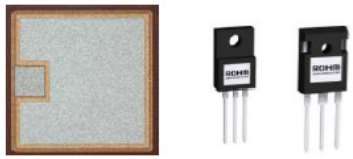
Improvement of efficiency and reduction of power loss



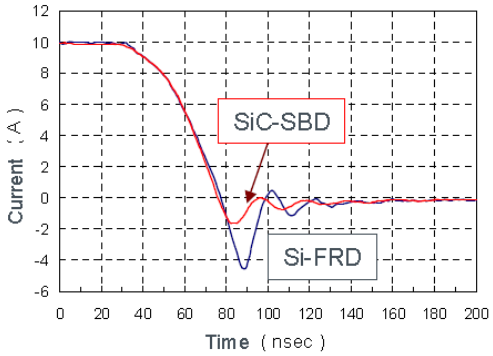
Downsizing of module, passive components and cooling system

SiC = silicon carbide

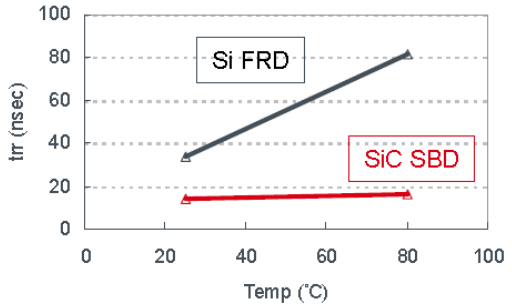
SiC MOSFET and module

	SiC SBD	SiC MOSFET	SiC Power Module
			
Features	- No reverse recovery current - Low temperature and current dependency - Lower Vf than competitors' equivalent products	- Low switching loss - Low RonA	- Full SiC module (SiC SBD + SiC MOSFET, 1200V 100A spec)

Switching waveform (600V 10A)

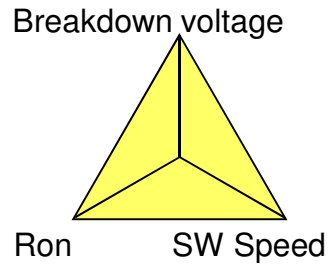
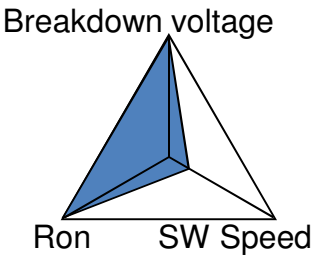
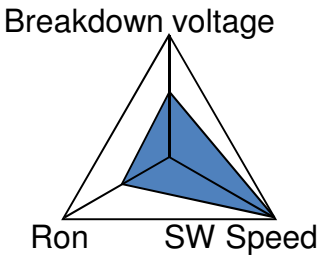


Temperature dependency (600V 5A)



IGBT = Insulated gate bipolar transistor, SiC = silicon carbide, MOSFET = metal oxide semiconductor field effect transistor

SiC MOSFET – Comparison with Si Switching Devices

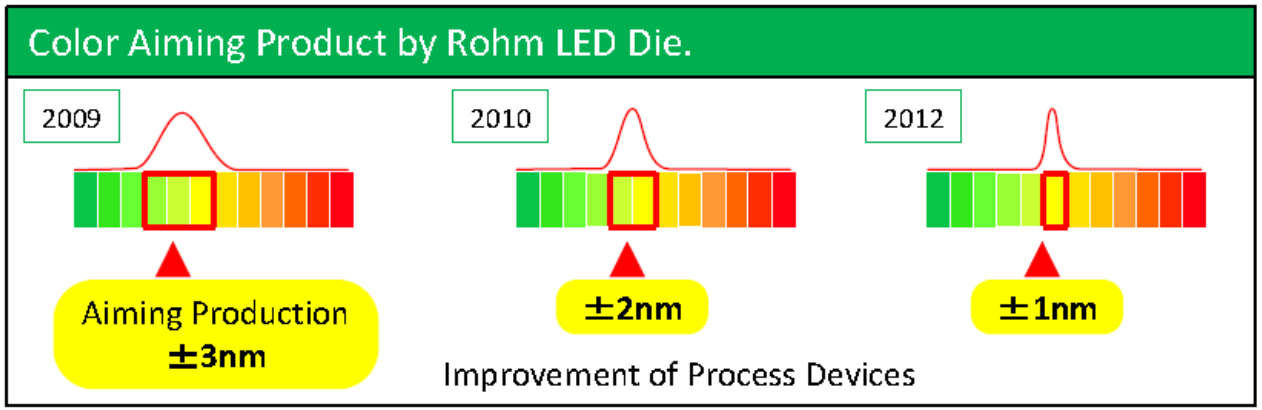
	SiC MOSFET	Si IGBT	Si Super-junction MOSFET
Balance of features			
Breakdown voltage	DS sample up to 1200V, and higher in future	High	Up to around 900V
Ron	Low	Low but high at lower current due to threshold voltage	Low but increasing at high temperature
Switching speed	Rapid	Limited switching frequency and existence of tail current when turn-off	Rapid

IGBT = Insulated gate bipolar transistor, SiC = silicon carbide, MOSFET = metal oxide semiconductor field effect transistor

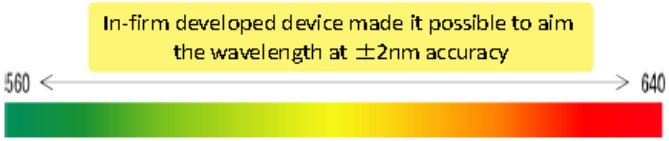
LED

PLCC2 LED Line-up

High brightness, higher than the current line-ups.
Adoption of the ultimate level 4 elements(AlInGaP) by ROHM device technology.

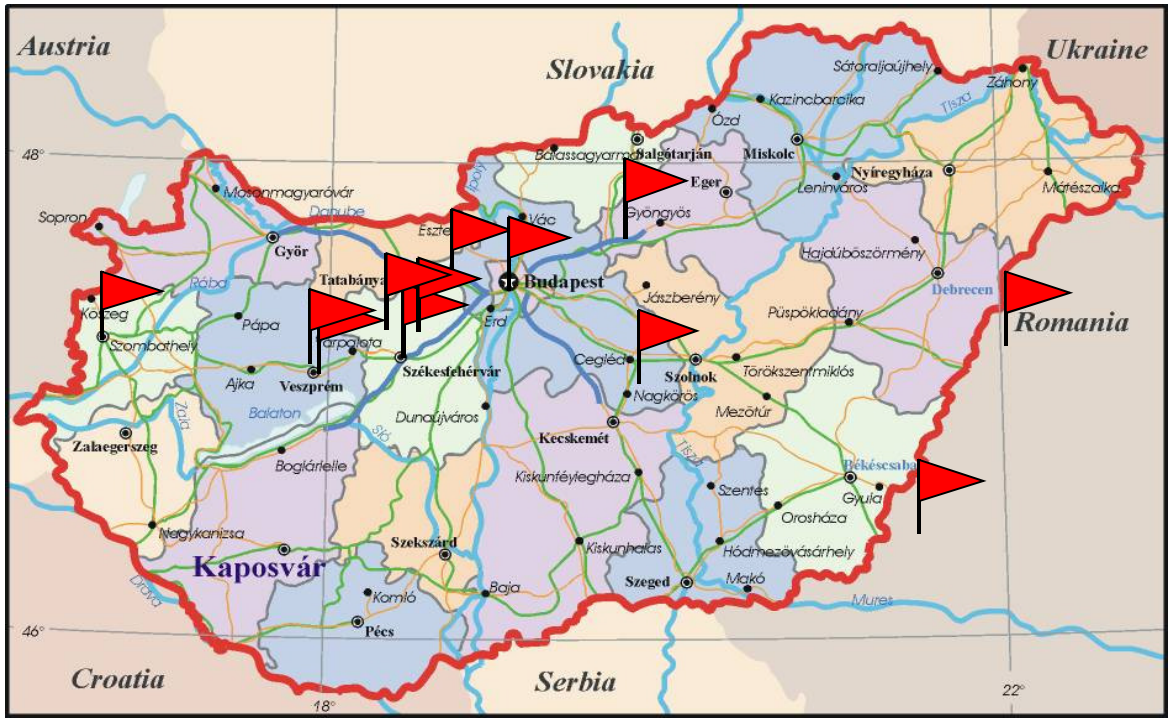


We can archive request color from you to use our own LED die.



LED = light emitting diode

… és kik használják nálunk ezeket az eszközöket ?
“1st tire” beszállítók



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YAZAKI

Visteon

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SEWS

Köszönöm a figyelmet!