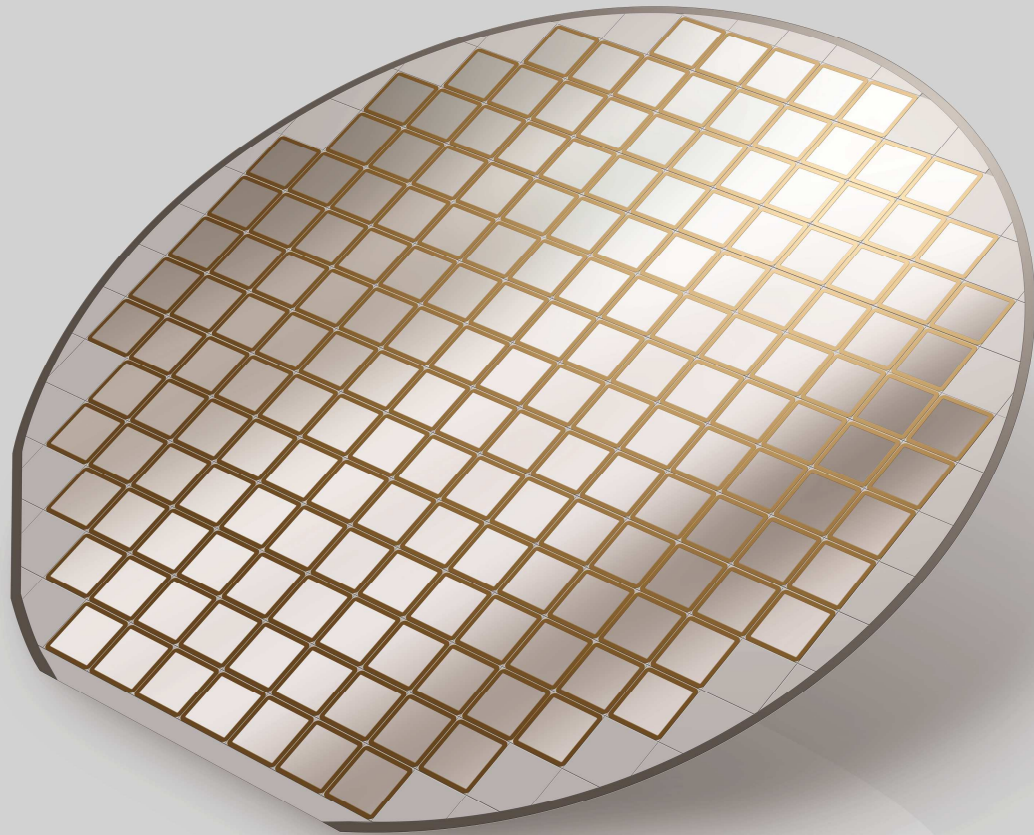


SEMICELL Chips

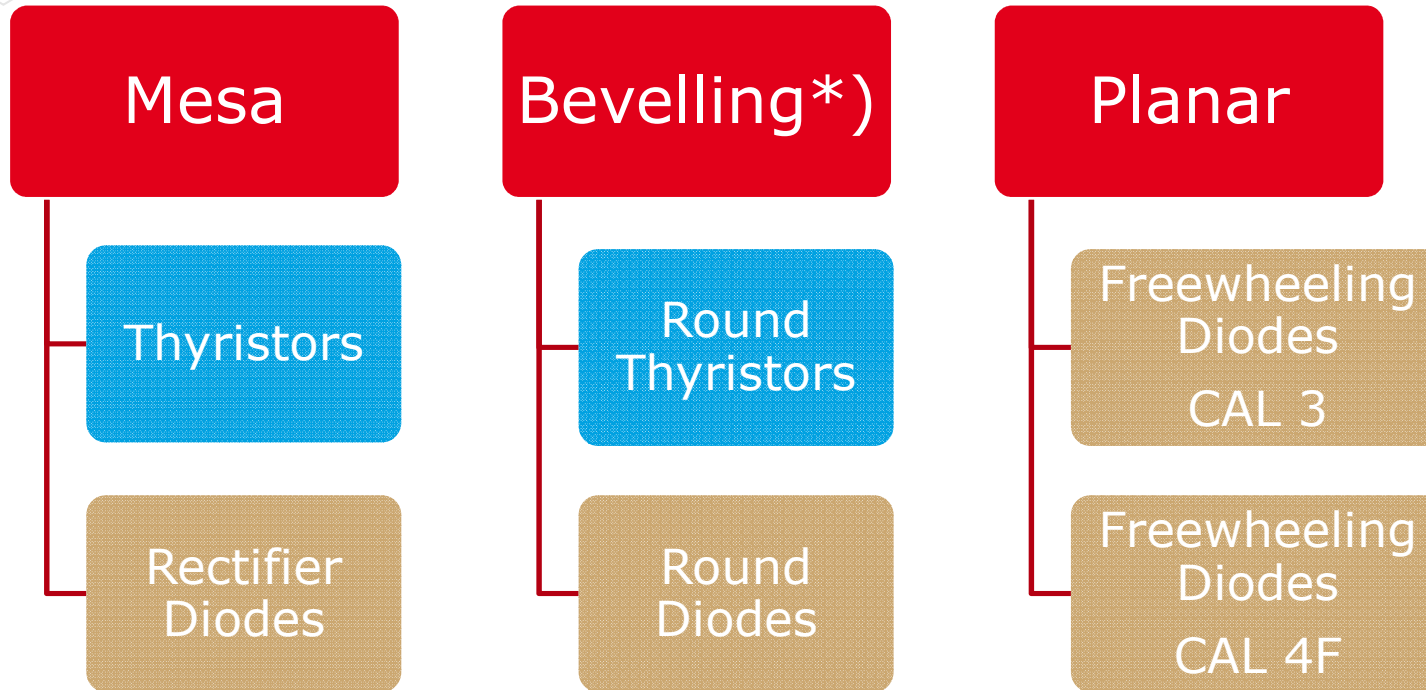
SEMIKRON's Bare Die Products

June 2014

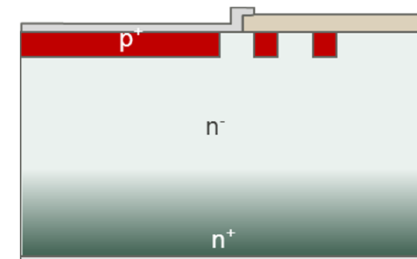
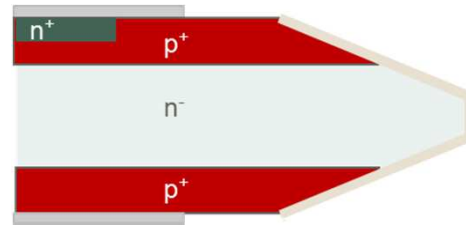
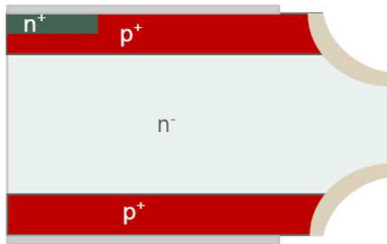


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Technology Overview

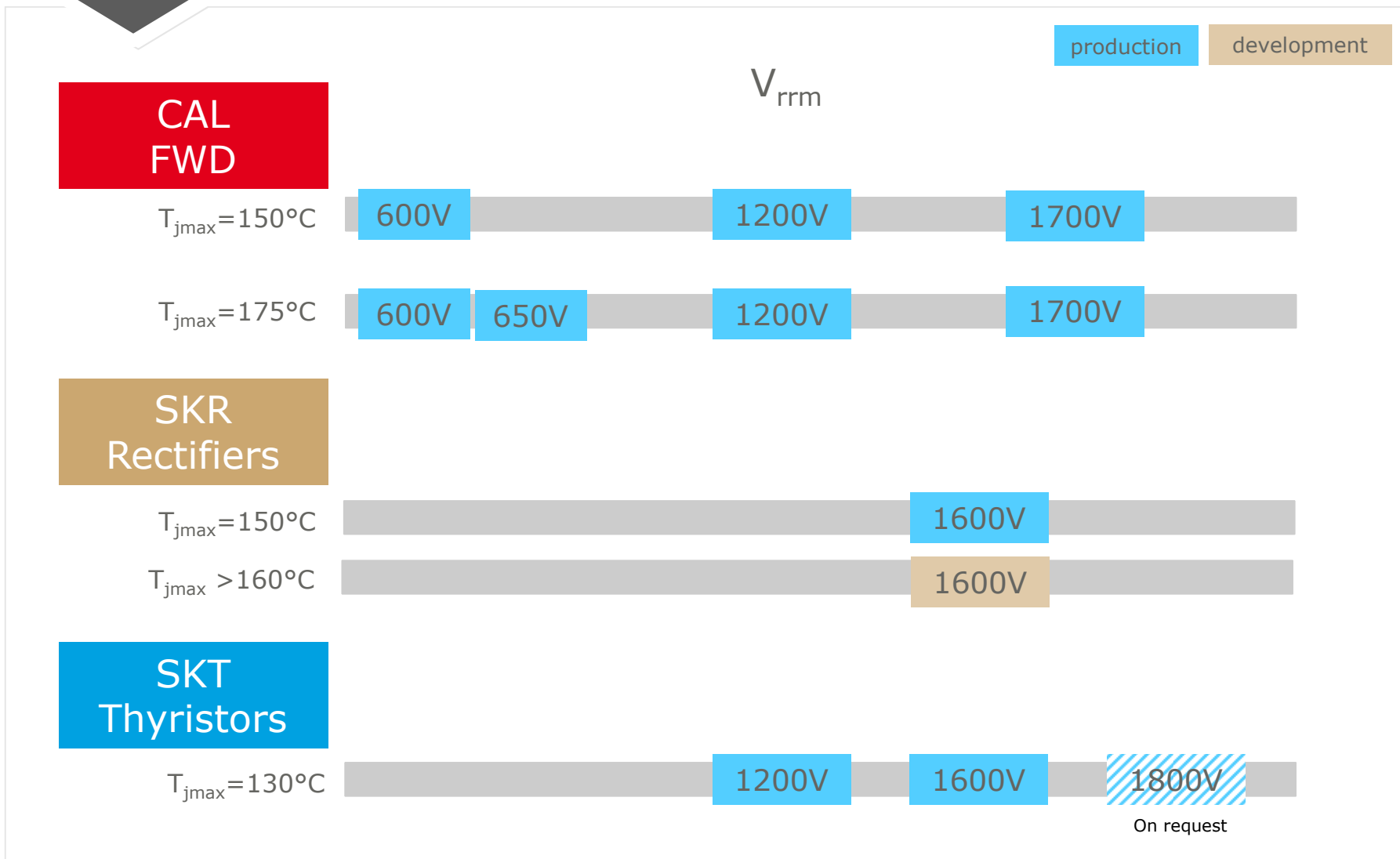


*) finalized in SK Brazil



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Overview Voltage Classes (only square devices)



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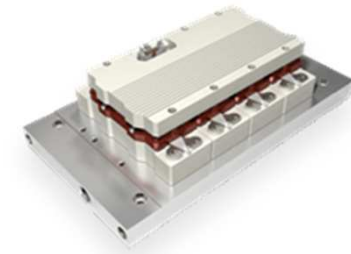
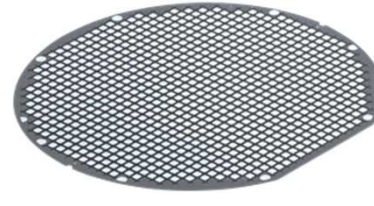
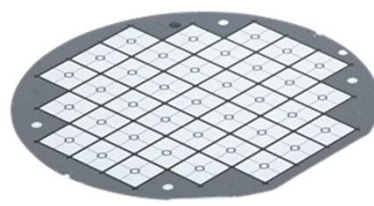
Outstanding Application Expertise

SEMIKRON chips

**used in a wide
range of assemblies
and modules**

**for multi-purpose
applications**

drives, elevators, UPS,
renewables,...



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Major Benefits of SEMICELL chips

Decades of experience in the field & outstanding application expertise

- all SEMICELL chips are used in SEMIKRON products in various applications

Robust Designs

- high reliability
- excellent bond/solder/sinter contact properties
- CAL 4 first 1200V freewheeling diode for $T_{jmax} = 175^{\circ}\text{C}$

Different carrier options based on customer's value chain

- un-sawn wafers
- Sawn On Frame (SoF)
- waffle packs/trays

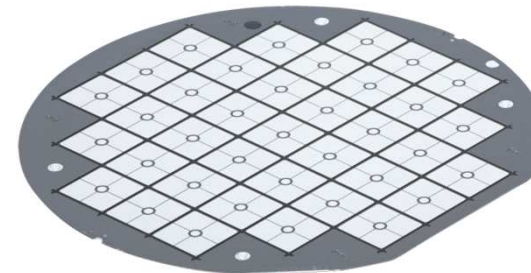
Service

- short response time
- flexible and customer specific solutions

Thyristors – Overview

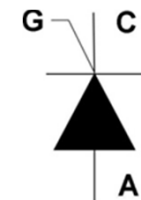
SKT

$T_{jmax} = 130^{\circ}\text{C}$



blocking voltage	usable current	surge current
1200V (/12)	25 ... 130 A	300 ... 1950 A
1600V (/16)	45 ... 400 A	280 ... 8200 A
1800V (/18)	On Request	

major product line



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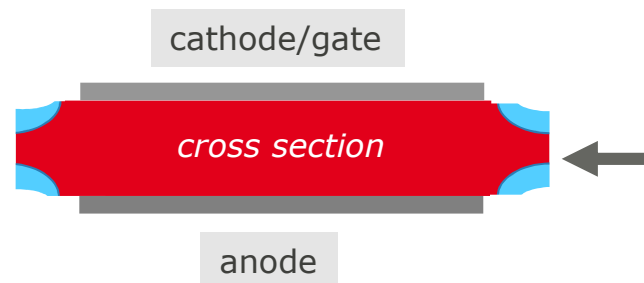
Thyristors – Design

Two top metallizations

(1) bondable contact (standard)

- 8 μm Aluminum for high current density, thickest contact of all competitors
- thick wire bonding ($<500\mu\text{m}$) \rightarrow high surge currents

(2) solderable contact for reflow- or preform-soldering



small edge width due to double mesa technology

- high current density
- saves space in your design

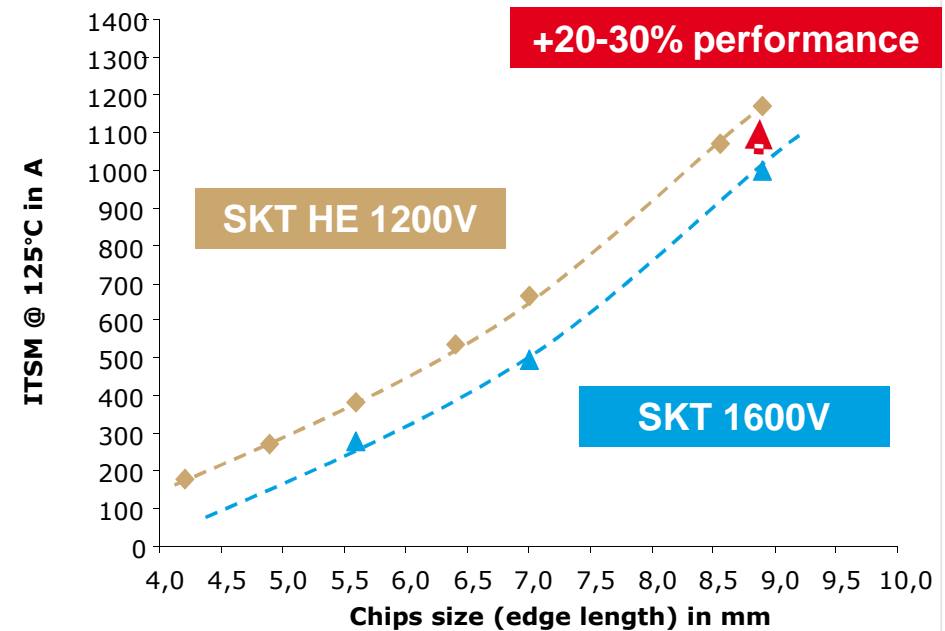
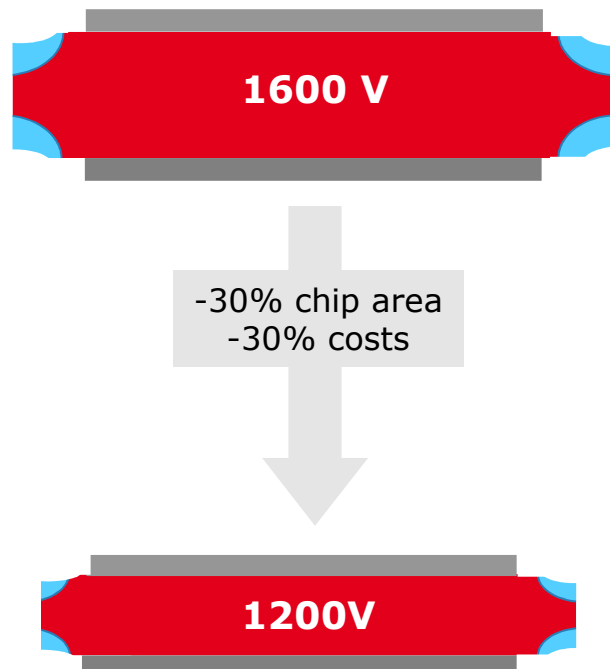
Bottom contact

- reflow- or preform-soldering
- excellent solderability up to large chip sizes

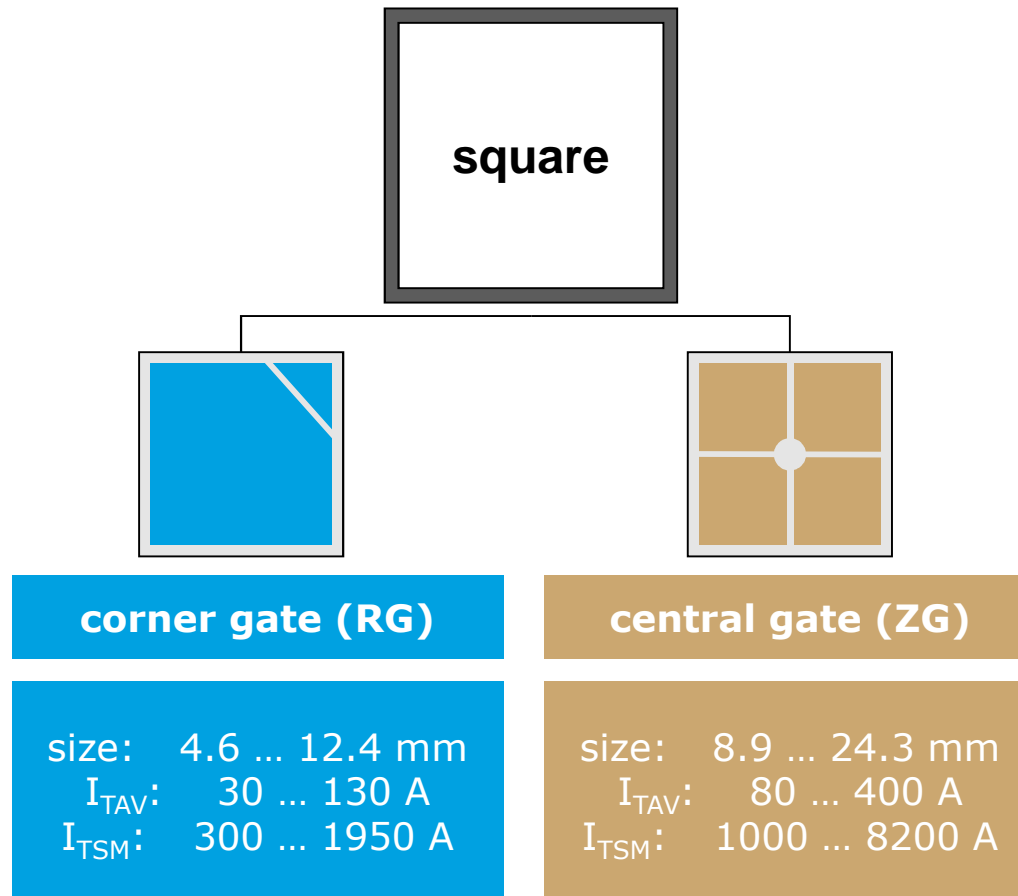
Dedicated Thyristor Technologies for 1200/1600 V

SKT HE 1200V (pilot production running)

- reduced chip thickness
- reduced edge width



Thyristor – Gate Configurations



Naming Convention of SEMIKRON Chip Products

Thyristors

SKT **7,0** **Qu** **RG** **bond** **/18**

SK: SEMIKRON
Thyristor

feed size
(7,0 = 7.0 mm)

Qu: quadratic
chip layout

gate design
RG (corner gate),
ZG (central gate)

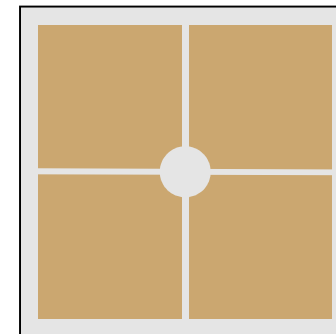
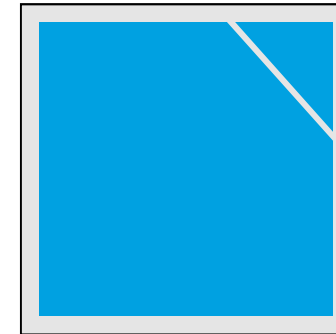
top contact
bond/bo (bondable),
löt Ag (solderable)

(optional)
/18 (1800 V V_{rrm})
default: 1600V

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SEMIKRON Thyristors – Summary

- cost saving with voltage class specific designs
- reliable & robust: high yielding products
- high current density due to mesa technology
- flexible assembly layouts/bond patterns due to corner and central gate versions



Rectifiers – Overview

SKR/SKN

$T_{jmax} = 150^{\circ}\text{C}$



**blocking
voltage**

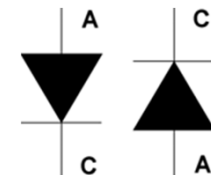
1600V (/16)

**usable
current**

18 ... 630 A

**surge
current**

200 ... 9450 A



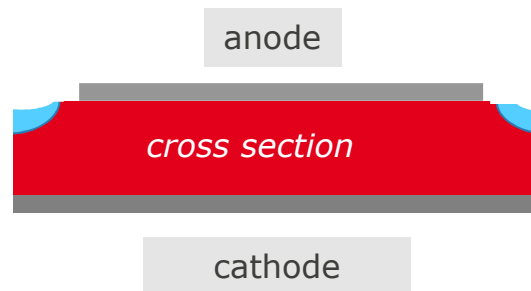
Rectifiers – Design

Two top metallizations

(1) bondable contact (standard)

- 8 μm Aluminum for high current density, thickest contact of all competitors
- thick wire bonding (500 μm) → high surge currents

(2) solderable contact for reflow- or preform-soldering



small edge width due to mesa technology

- high current density
- saves space in your design

Bottom contact

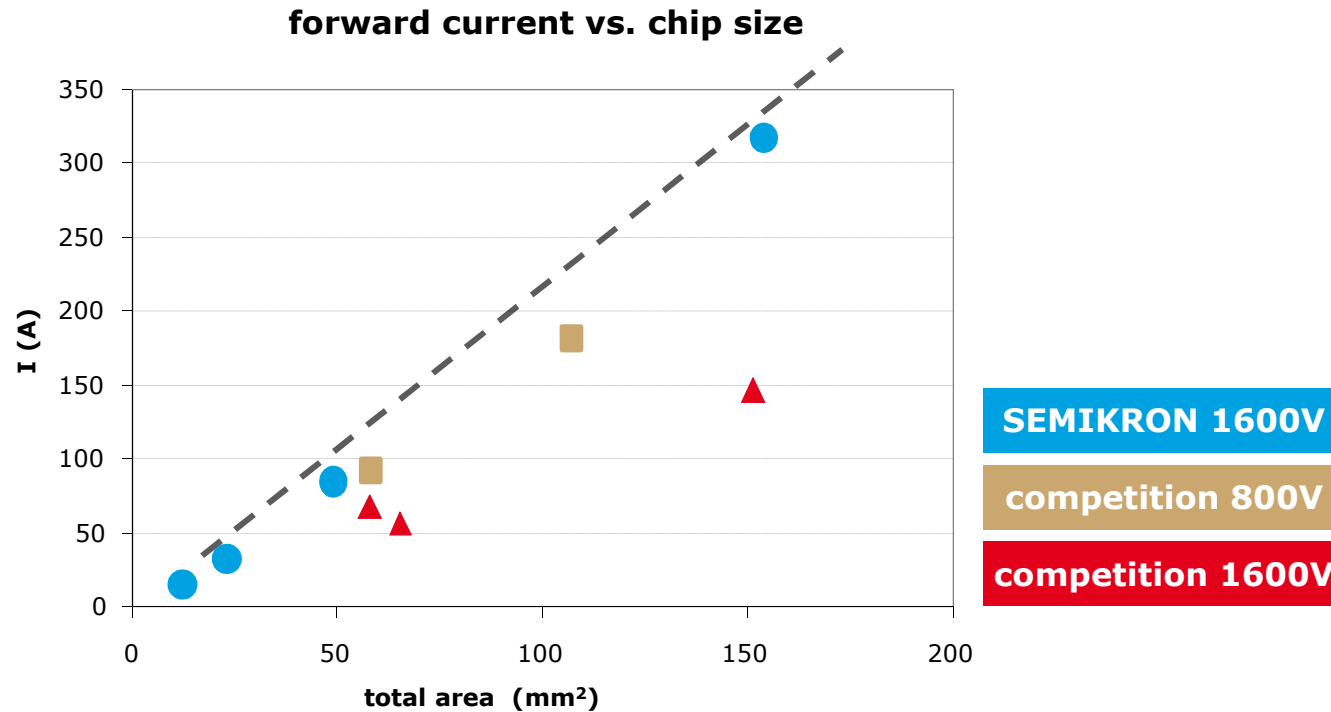
reflow- or preform-soldering

excellent solderability up to large chip sizes

- configurations w/ bondable cathode (SKN) available

Rectifiers – Cost Savings by Small Chips

- Semikron provides higher current at same chip size
- Or: same current with smaller chip size – lower costs

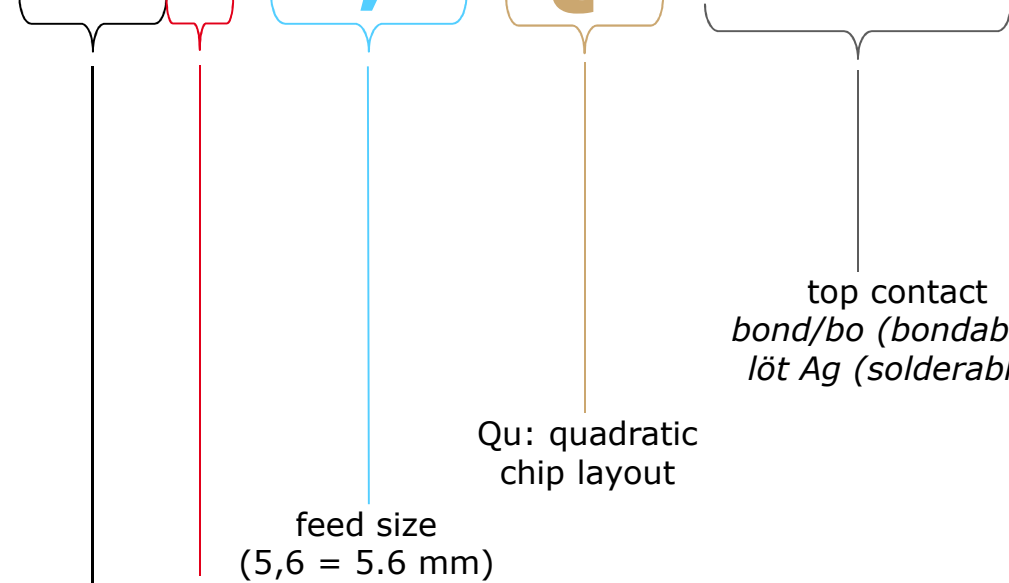


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Naming Convention of SEMIKRON Chip Products

Rectifiers

SKR 5,6 Qu bond



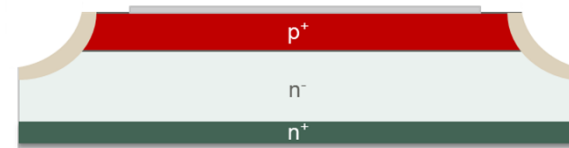
Rectifier
*R (anode on the top),
N (cathode on the top)*

SK: SEMIKRON

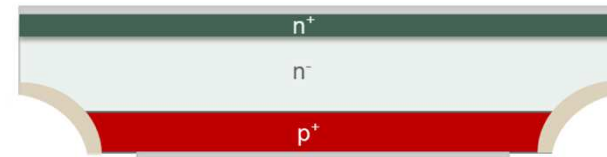
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SEMIKRON Rectifiers – Summary

- reliable & robust: high yielding products
- high current density due to mesa technology
- reduces chip costs
- T_j up to 150°C



SKR



SKN

CAL Freewheeling Diodes – Overview

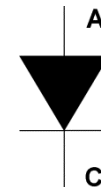
SKCD

$T_{jmax} = 150^{\circ}\text{C}$ and 175°C

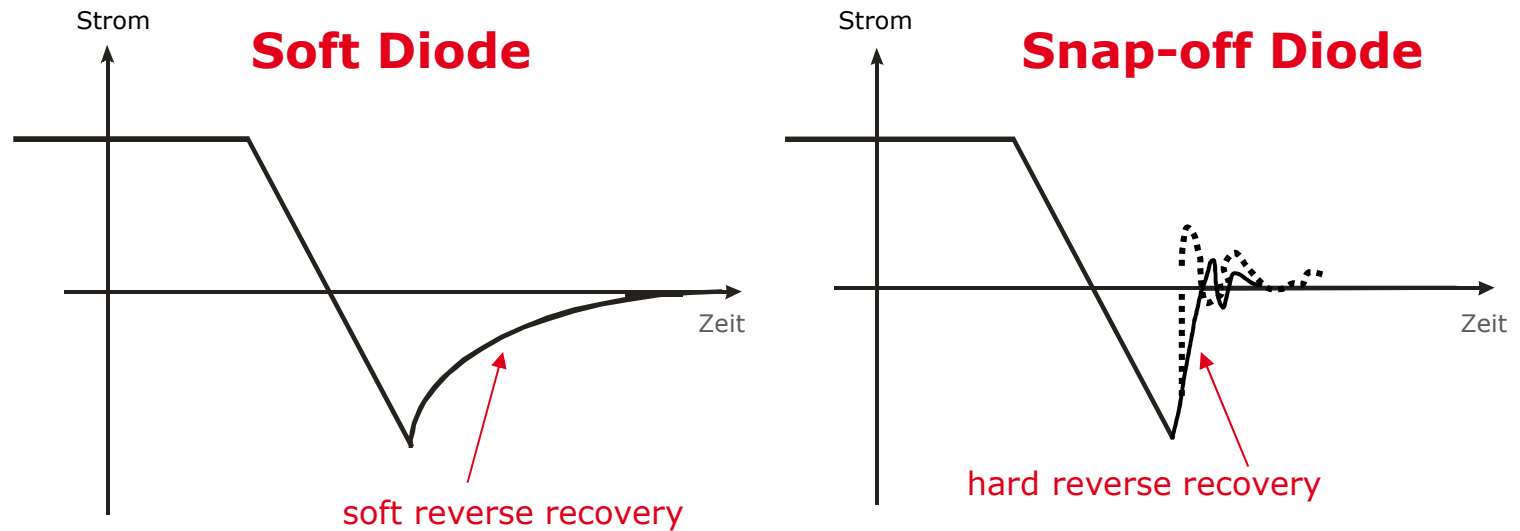
Freewheeling diodes based on Controlled Axial Lifetime (CAL) technology

Soft Recovery Behaviour

blocking voltage	Chip Area	$I_F(\text{IGBT})$
600 V	4 ... 121 mm ²	10 ... 210 A
650V	<i>tbd</i> ... 81 mm ²	<i>tbd</i> ... 200 A
1200 V	6 ... 121 mm ²	6 ... 160 A
1700 V	47 ... 81 mm ²	55 ... 150 A



Turn-Off and Softness



CAL diode is a soft diode

PRO

low overvoltage

lower switching losses in diode

CON

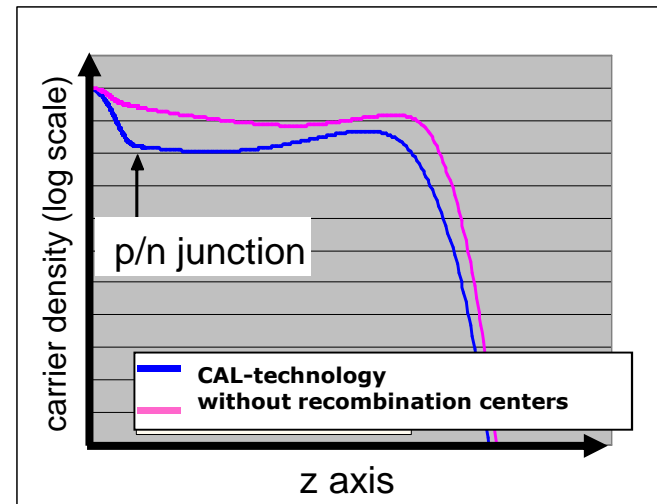
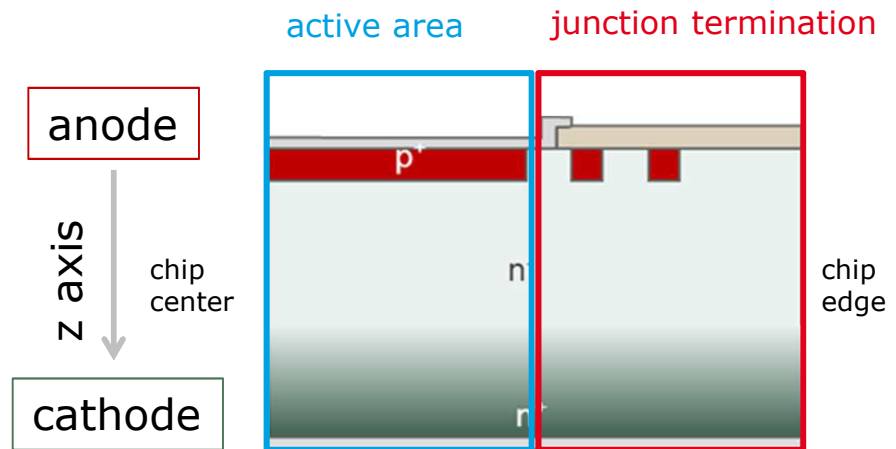
higher switching losses in diode

higher overvoltage

Controlled Axial Lifetime Technology

Developed by SEMIKRON in 1992

- power diode based on p-i-n design.
- reverse recovery behaviour can be influenced by lifetime of charge carriers (electrons, holes)
- CAL: lifetime of charge carriers not uniform by going from anode to cathode but changing along the z axis (therefore „controlled axial lifetime“)
- soft recovery behaviour is achieved by locally reducing the lifetime close to the pn junction



Optimized CAL Product Solutions

correct choice of CAL diode type depends on specific application and accompanying IGBT

CAL3

CAL4F

**blocking
voltage**

600 V

CAL 600V HD (CAL 600V I3)

650V

CAL 650V I4F

1200 V

CAL 1200V HD

CAL 1200V I3

CAL 1200V I4F

1700 V

CAL 1700V HD

CAL 1700V I

CAL 1700V I4F

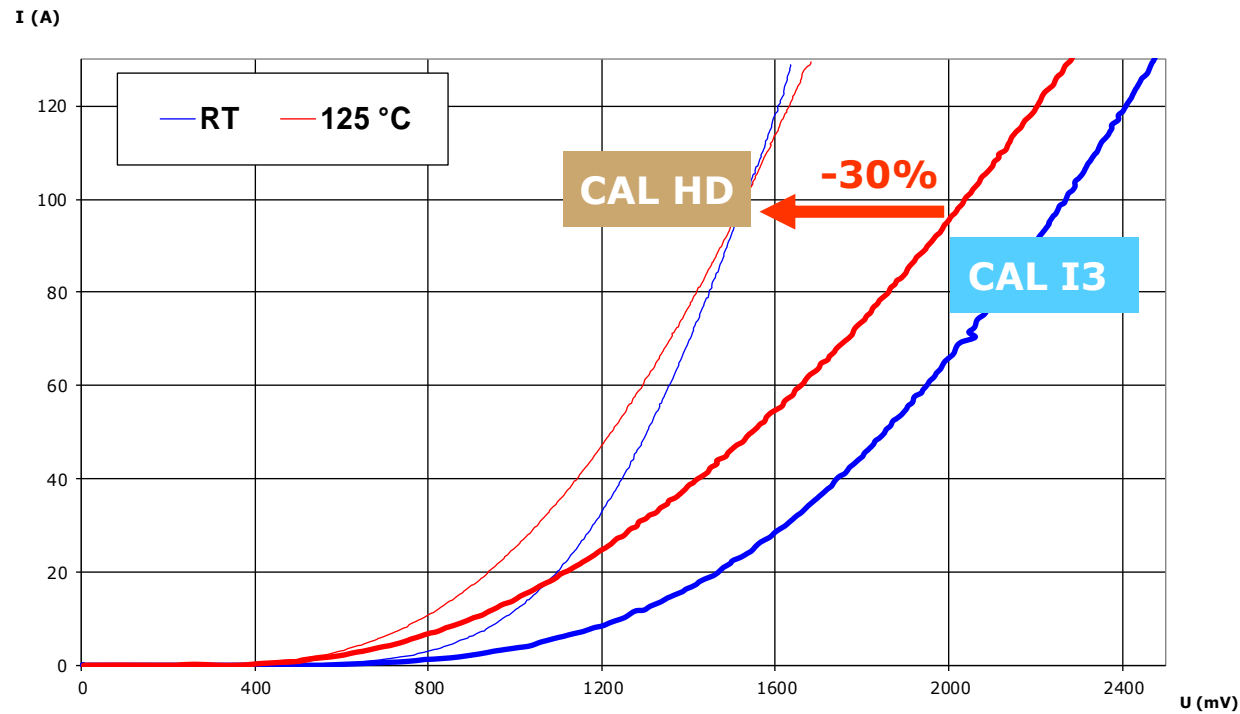
5 kHz~8 kHz

20 kHz Recommended f_{sw}

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CAL 1200V I3 vs. HD: Static Losses

- CAL HD (**H**igh **D**ensity) is optimized for low static losses
- ideal for low switching frequencies

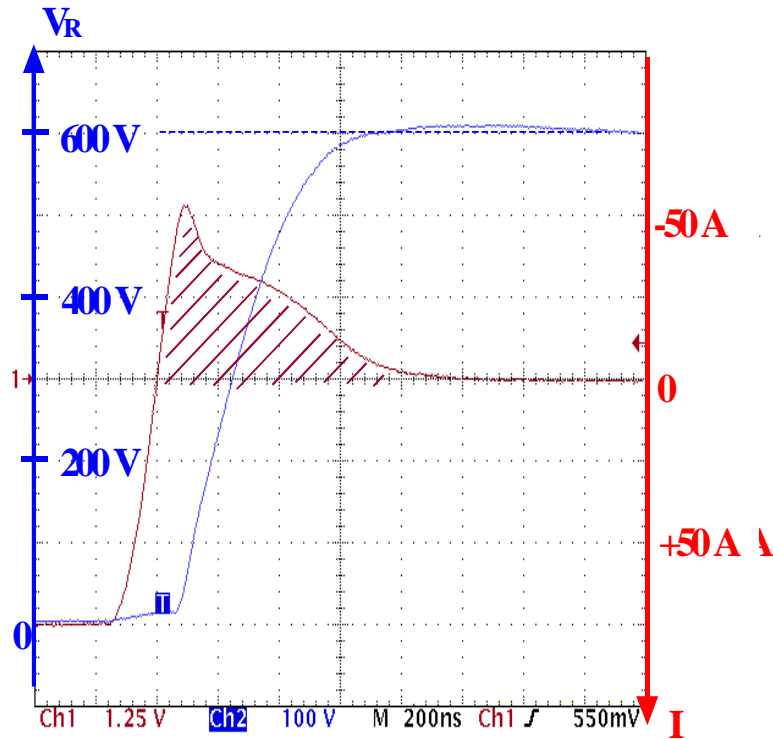


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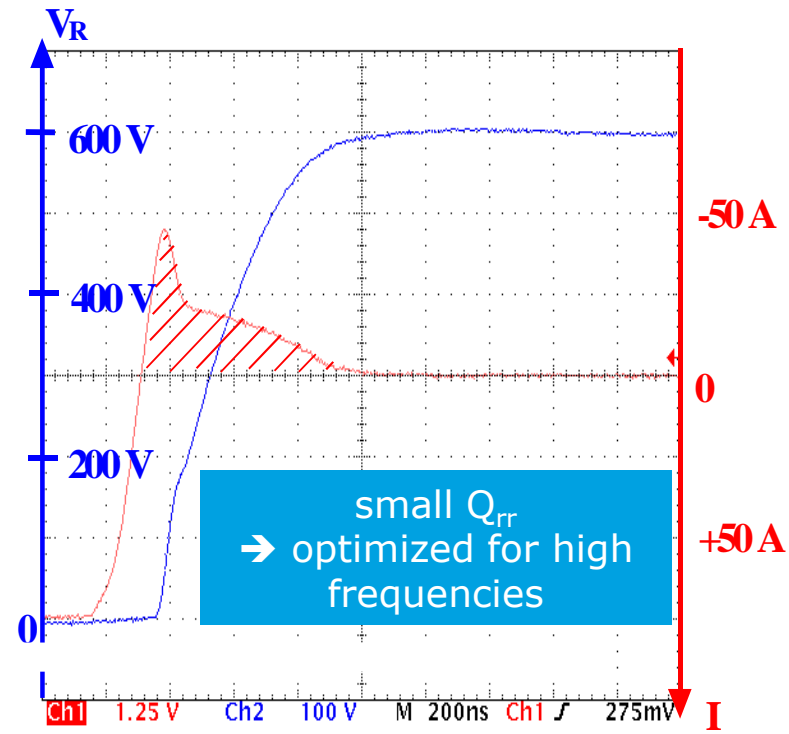
CAL 1200V I3 vs. HD: Dynamic Losses

Switching at $I_F=75\text{ A}$, $V_R=600\text{ V}$, $dI/dt=800\text{ A/ms}$, $125\text{ }^\circ\text{C}$

CAL HD



CAL I3



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A Special Case: 600V CAL HD

In 600V class, SEMIKRON followed a different design concept for HD version as compared to 1200V/1700V.

A 30% higher current density at same switching losses could be achieved

		CAL I3	CAL HD
	Condition	SKCD 06 C 060 I3	SKCD 06 C 060 I HD
I_F	1.35 V, RT	8 A	12 A
Q_{rr}	=8 A, $di/dt=120 A/\mu s$, $T=125^\circ C$	0.65 μC	0.66 μC
I_{RRM}	=8 A, $di/dt=120 A/\mu s$, $T=125^\circ C$	4.2 A	4.2 A

Therefore, CAL 600V HD is the best solution also for fast switching applications
CAL 600 V HD is rated for $T_{jmax} = 175^\circ C$

CAL4F: 4th Generation Freewheeling Diode

CAL4F is designed for $T_{jmax}=175^{\circ}C$

Compatible with IFX IGBT4, Fuji V-IGBT, etc.

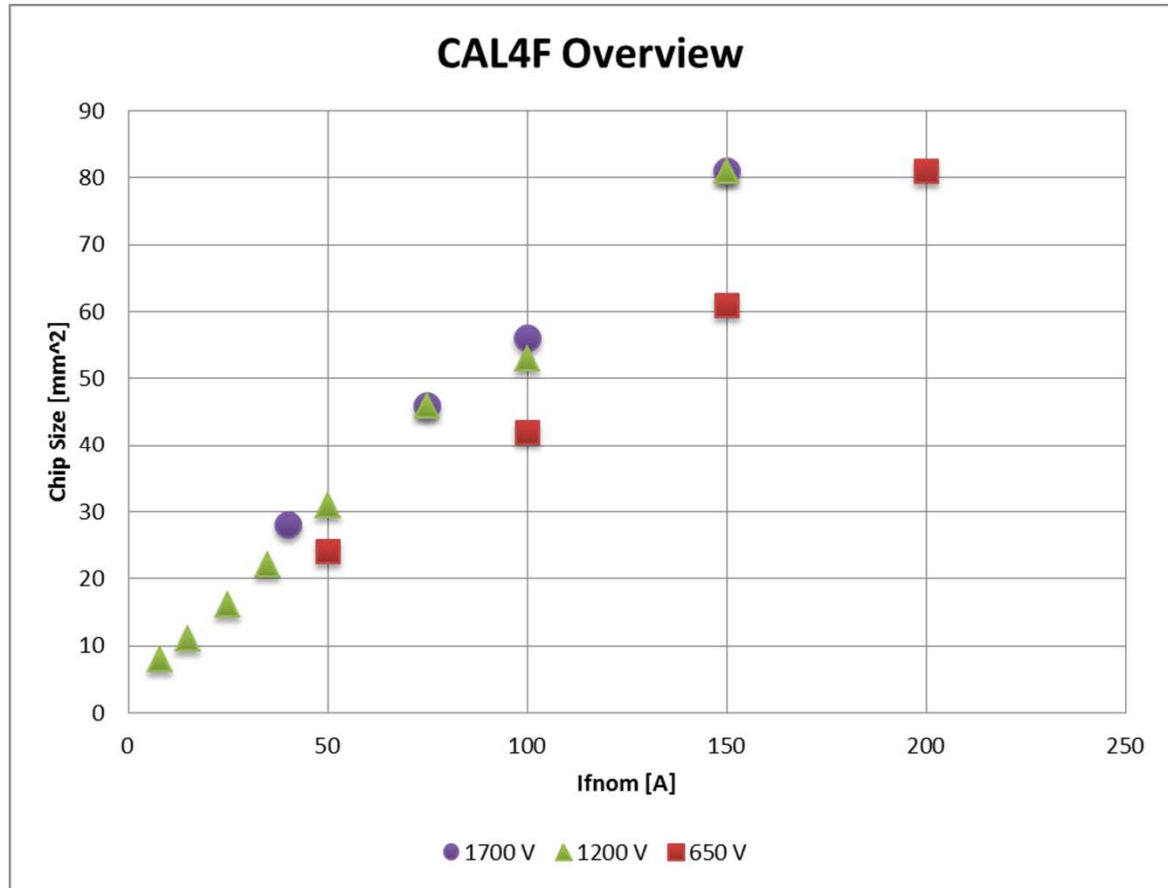
650V/1200V/1700V CAL4F families available

Enhanced humidity robustness

Key Feature	CAL I3 1200V	CAL I4F 1200V
passivation	glass	oxide/PI
max. junction temperature	150°C	175°C
recommended operation temp.	125°C	150°C
relative chip size	100 %	~75 %
optimal frequency range	> ~8 kHz	> 8 kHz
current density	123 A/cm ²	188 A/cm ²

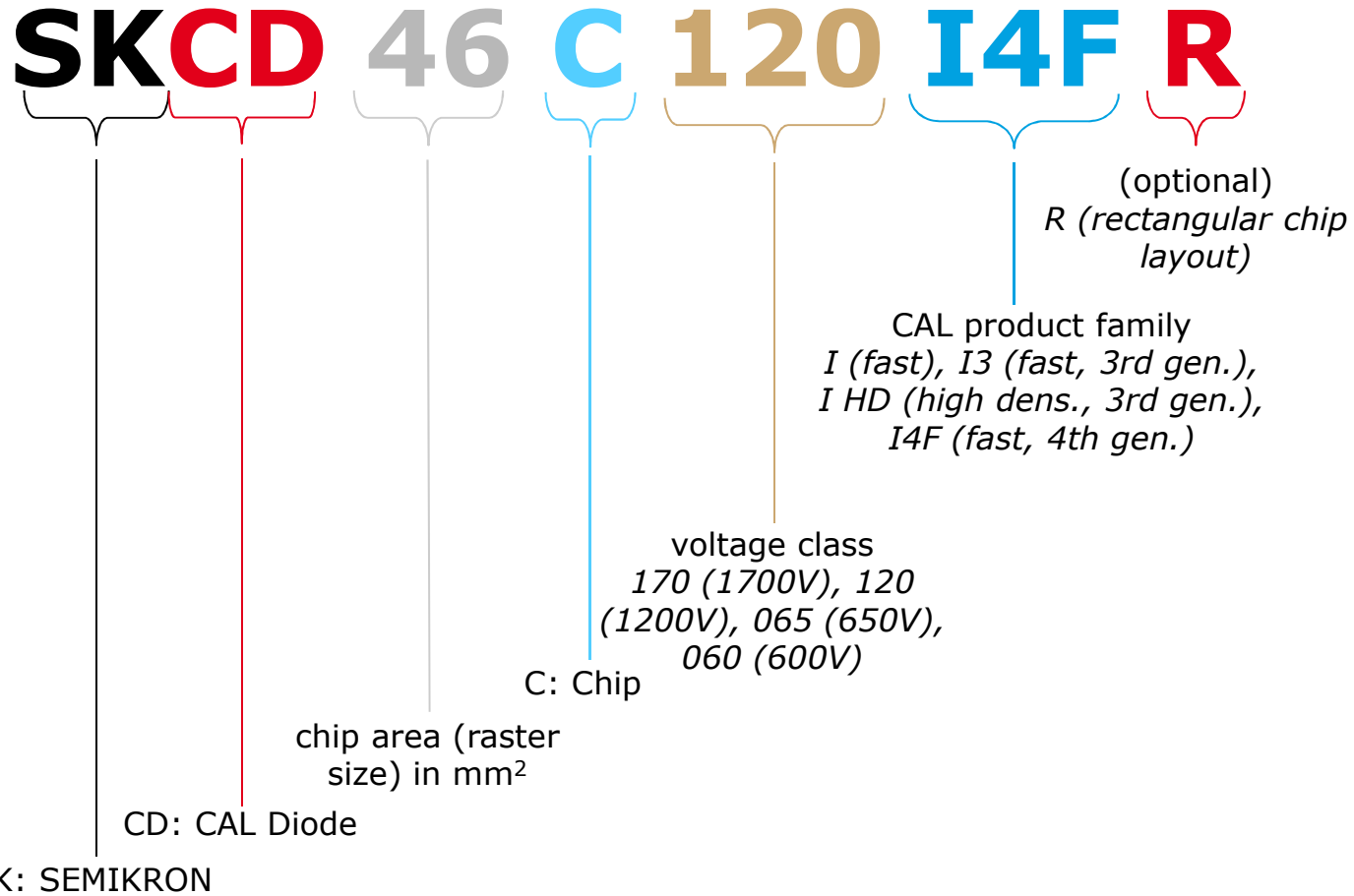
Overview CAL4F Portfolio

- Further expansion of portfolio planned



Naming Convention of SEMIKRON Chip Products

Freewheeling (CAL) Diodes



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SEMIKRON CAL Freewheeling Diodes – Summary

- soft recovery behaviour
- high dynamic robustness
- proven compatibility with different IGBTs
- T_{jmax} up to 175°C : high performance



Thank you for
your attention!