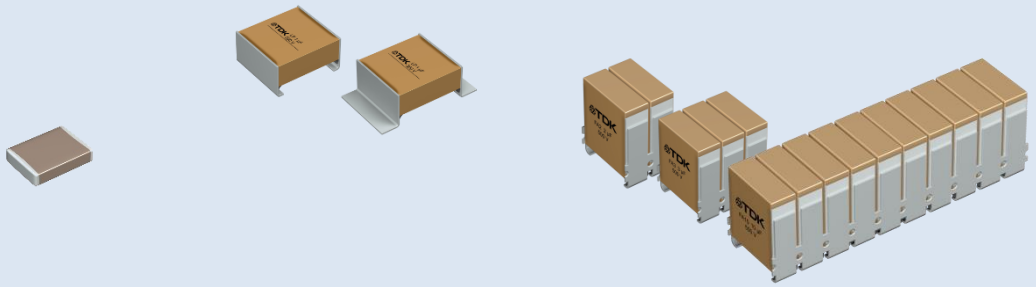
Attracting Tomorrow

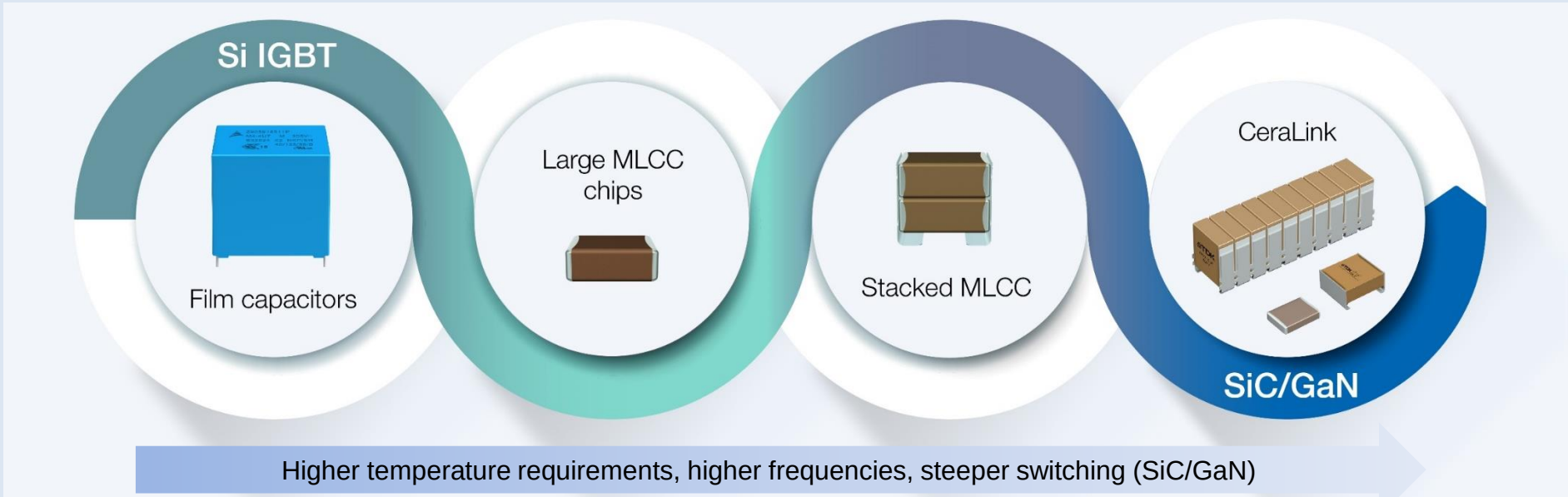
CeraLink

Ceramic capacitors for fast-switching power electronic circuits



TDK Electronics AG
Piezo & Protection Devices Business Group
Munich, Germany
April 2024

Capacitor Technology Requirements Moving to Wide Bandgap



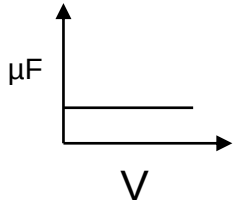
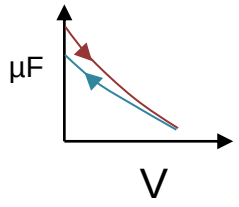
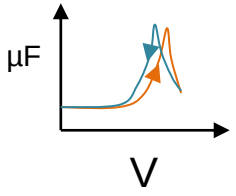
- Smaller
- Higher operating temperature
- Lower ESL
- Higher frequency
- SMD
- Higher ripple current ratings

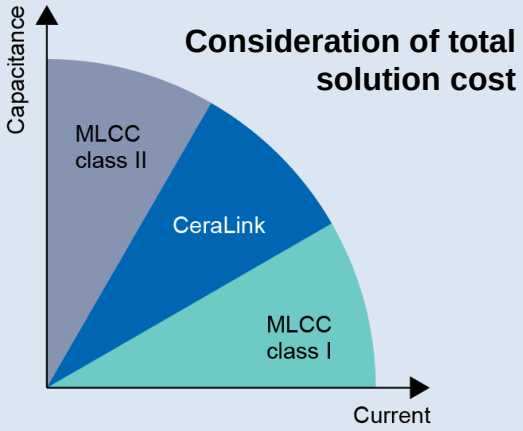
- Lower ESL
- Mechanically more robust

- Smaller solution
- Higher operating temperature
- Lower ESL
- Higher ripple current ratings

CeraLink: Special Behavior 1/2

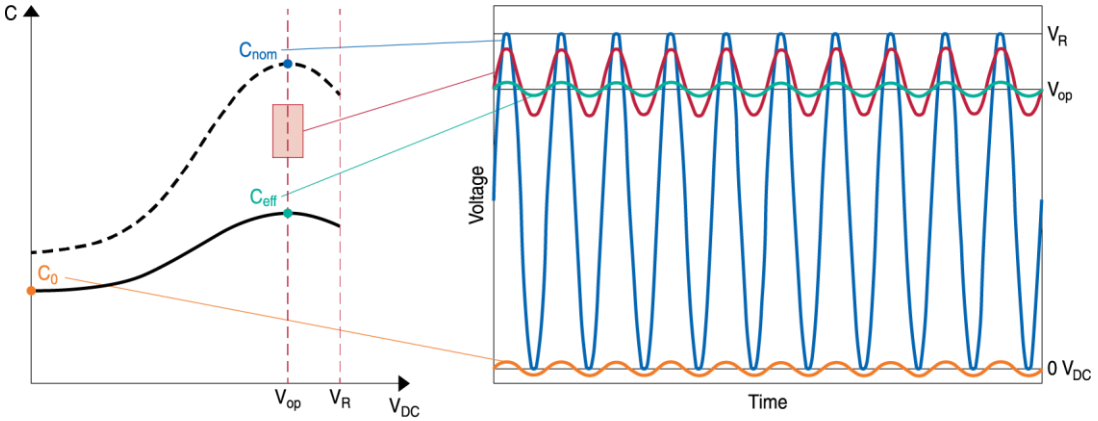
Some differences to MLCC

Linear	Ferroelectric	Antiferroelectric
MLCC class I	MLCC class II	CeraLink
		



Feature: Positive bias behavior

- Increasing capacitance with DC bias between 0 V and V_{op}
- Best in class capacitance density at operating point (V_{op} & T_{op})



C_0 : 0 V_{DC} plus small superimposed AC signal (0.5 $V_{AC, RMS}$)
C_{eff} : 400 V_{DC} plus small superimposed AC signal (0.5 $V_{AC, RMS}$)
C_{nom} : Value of large signal capacitance (C = dQ/dV) at V_{op} (simplified for the purpose of this picture)
$C_{(red\ area)}$: 400 V_{DC} plus large superimposed AC signal (20 $V_{AC, RMS}$)

Typical snubber application
Typical DC-Link application

More to this in the CeraLink Technical Guide

CeraLink: Special Behavior 2/2

At high temperature

- Operating temperature up to +150 °C
- Low losses at high temperature
- Low leakage current
- No thermal runaway

- Generally low self-heating AND self-heating supports CeraLink to come to temperature for good performance

At high frequency

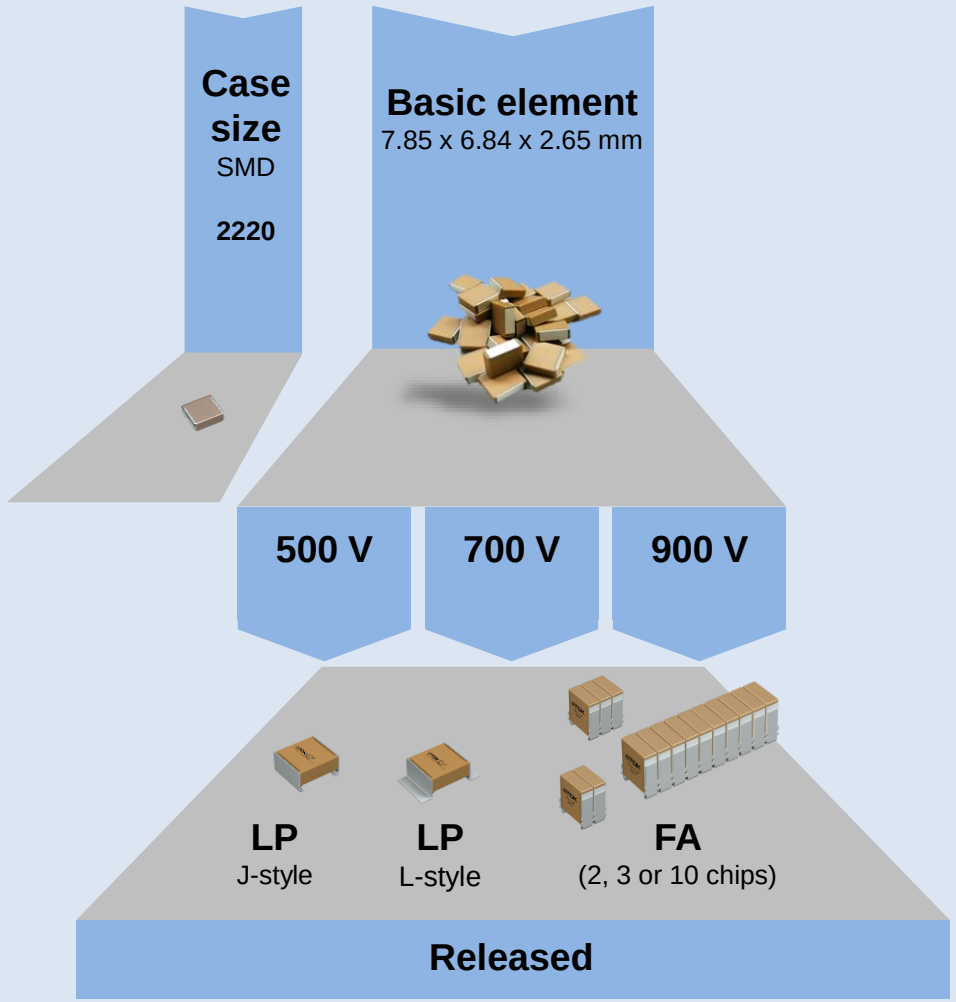
- Optimal frequency in the range of 100 kHz to 1 MHz
- Minimal ESR due to low-loss copper electrodes and HF-suited mechanical construction
- Typ. ESR @ 25 °C, 1 MHz*: 3-45 mΩ
- Typ. ESL*: 2-4 nH
- No limitation of dV/dt
- Temperature decrease with rising frequency

Due to low losses at high temperature and high frequency, CeraLink can carry more current under these conditions

Measurement condition	MKP film capacitor	MLCC class II (BTO)	CeraLink
Typical capacitance density @ DC link voltage, 20 V_{RMS}, 25 °C	0.7 µF/cm³	2.5 µF/cm³	**4.9 µF/cm³**
Typical current rating per capacitance @ 100 kHz, 105 °C	< 1 A/µF	< 4.5 A/µF	**11 A/µF**

* varies with series and voltage class

CeraLink: Product Portfolio and Outlook



Series	Rated voltage		
	500 V	700 V	900 V
Low profile **LP (L /J-style)**	1 µF	0.5 µF	0.25 µF
Flex assembly **FA2 / FA3**	2 / 3 µF	1 / 1.5 µF	0.5 / 0.75 µF
Flex assembly **FA10**	10 µF	5 µF	2.5 µF
2220 series **2220** **Soft termination**	0.25 µF @ h 1.4 mm *		0.056 µF @ h 1.6 mm *

* also available as standard termination

CeraLink: Ideal for Demanding Applications (Examples)

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High-voltage applications in xEVs

Power supplies for medical equipment

Test and measurement

Drives

Welding

Traction (SiC)

- Compact design
- Temperature
- High-voltage
- High current capability
- Low weight/ low size
- Low ESL
- Robust design

CeraLink: Known Customer Applications

Markets

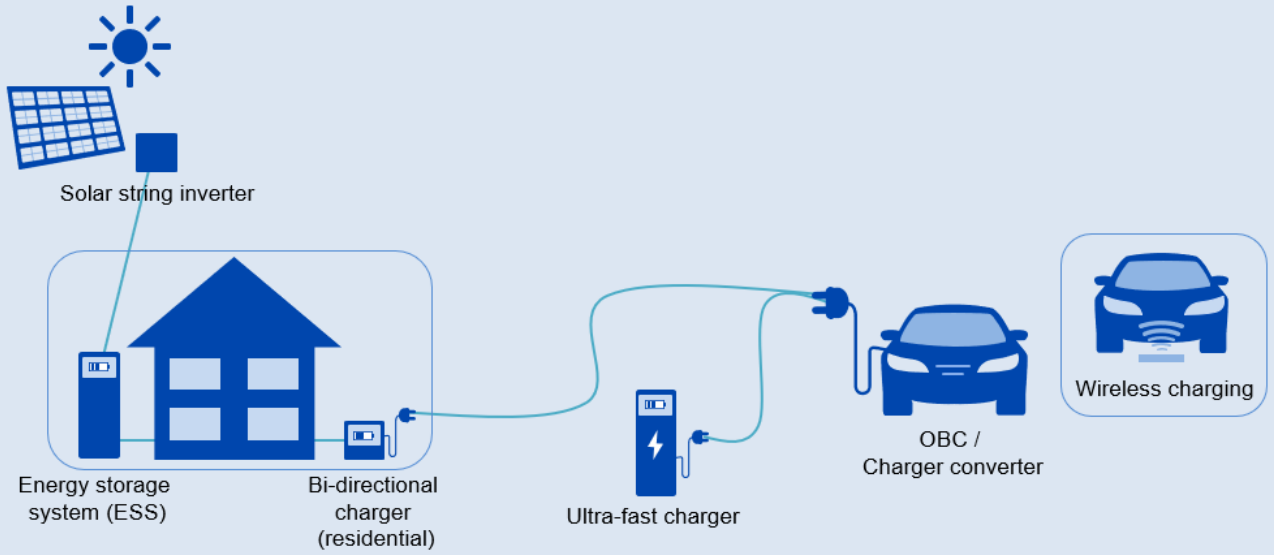
Automotive

- On-board charger (OBC)
- DC-DC converters
- Auxiliary inverters for xEVs (HV compressors, HV pumps, HV heaters)

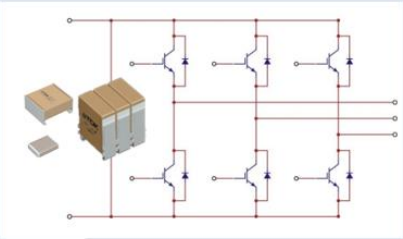
Industry

- Energy storage systems
- Power converter
- Solar inverters
- Drive inverters
- Power supplies like UPS, isolated power supplies

EV charging landscape



WBG power modules



CeraLink allows low inductive commutation loops as it is small, likes higher temperatures, and has low parasitics
→ allowing short rise/fall times and keeping voltage **overshoots low**
→ short rise/fall times result in **low switching losses** with WBG power semiconductors (SiC, GaN)

CeraLink: Ideal for Demanding Applications
Key Facts

Attracting Tomorrow

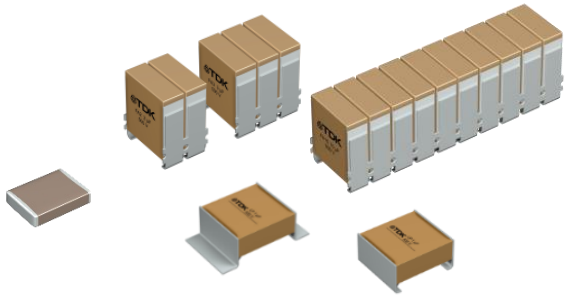
Known customer applications

Automotive

- OBC
- DC/DC
- Auxiliary inverters for xEV (HV compressor, HV pump, HV heater)
- Power modules for inverters

Industry

- Drives
- Energy storage systems
- Power converter
- Solar inverters
- Power supplies like UPS, isolated power supply



- Suitable for HV designs like **400 V/800 V**
- Increasing capacitance with DC bias and best in class capacitance density at operating point (V_{op} + T_{op})
- Supports **miniaturization** with low inductive design

Basic facts

Qualification based on AECQ-200

Manufacturing site in EU (Deutschlandsberg, AT)

Quality management system according to IATF 16949:2016

Soldering method: Reflow

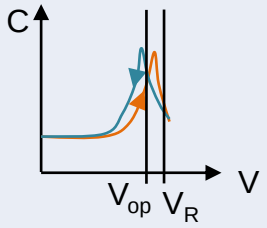
RoHS Compliant

Unique features

Innovative anti-ferroelectric ceramic material (positive bias behavior)

High cooling efficiency due to high thermal conductivity

Good self-regulating properties



Resulting advantages

High capacitance density

High current capability

Low ESL (typ. 3 nH)

Low losses at high frequencies and high temperatures (up to +150 °C)

No limitation in dV/dt

→ Ideal as snubber, filter capacitor or flying capacitor for SiC and GaN applications

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