Capacitors for hightemperature and power electronics

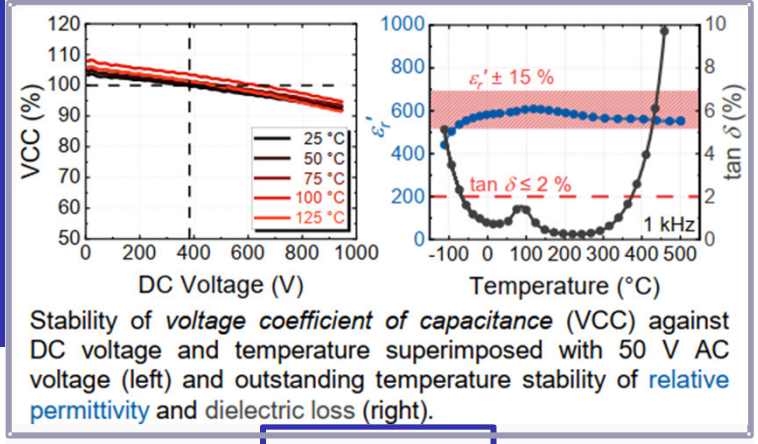
Sophisticated fabrication ensures component reliability of up to 1.5 kV and 375 °C with a capacitance stability of < ± 10%

STATUS QUO

The industrial utilization of multilayer ceramic capacitors grows rapidly. Applications like energy conversion, space and aviation as well as electric vehicles call for ever increasing demands. The problems are multifaceted. Capacitors can either be efficiently operated at certain voltages only or the capacitance is stable up to 120 °C only. For simultaneous workload of both high electric fields and extreme temperatures no capacitors are available with deviations of capacitance within industrial range of ± 15%.

OUR TECHNOLOGY

With our sophisticated approach we are able to prepare lead-free Na0.5Bi0.5Ti03-based multilayer ceramic capacitors. The components demonstrate highgrade electric stability and reliability under harsh conditions. This allows operation in an extensive temperature range from -67 – 375 °C with capacitance changes ≤ 10% and dielectric loss ≤ 2%. Furthermore, effective gating of the capacitors is possible with electric fields of up to 20 kV/mm (roughly 1 kV voltage) and temperatures up to 125 °C. Restricting capacitance changes to ≤ 10% and the huge advantages mentioned before are paving the way for high-temperature applications and power electronics. Thus, peak loads can be absorbed and smoothed at best.



Stability of *voltage coefficient of capacitance* (VCC) against DC voltage and temperature superimposed with 50 V AC voltage (left) and outstanding temperature stability of relative permittivity and dielectric loss (right).

BENEFITS

► Component reliability up to 1.5 kV and 375 °C

► Outstanding capacitance and temperature stability over huge voltage ranges

► Independent designing of capacitor's rated voltage

► Low values for equivalent series resistance (ESR) and inductance (ESL)

APPLICATION POSSIBILITIES

The capacitors can be utilized for renewable energies; for instance, wind turbines or solar power systems. Due to the outstanding temperature and capacitance stability. Furthermore, within power electronics for electric vehicles to effectively filter and smooth input loads at elevated temperatures. The approach of lead-free materials enables sustainable usage of the capacitors

COMMERCIALIZATION OPPORTUNITIES

There are various possibilities for cooperation between the industrial partner and TU Darmstadt: from an exchange with the know-how carriers of the technology up to a close cooperation in case of further development needs. The technology is protected by intellectual property rights and can be used by the industry partner after a sale or licensing agreement.

CURRENT STAGE OF DEVELOPMENT TECHNOLOGY READINESS LEVEL (TRL)

9	Product ready to launch
8	
7	Prototype
6	
5	
4	
3	Proof of Concept
2	
1	Idea

Manufactured capacitors are in the state of prototyping (Level 7): Demonstrators can be installed and tested under real conditions. Comprehensive measurements regarding reproducibility and circuit designing were conducted. Obtained serial resistances and inductances support implementation. Applicationoriented knowledge of degradation, cycling, and dielectric breakdown strength were evaluated as well.

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