

Capacitors News and Trends

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ABSTRACT

EPCI is continuously collecting passive components news since 2015. The passive component industry is currently going through many challenges facing the new requirements from modern electronics in various applications and directions. On one side, the consumer electronics is moving towards applications such as wearable applications with IoT communication capabilities, supported by the upcoming 5G telecommunication infrastructure, on the other side there are number of demanding new requirements related to energy storage, renewable energies or automotive generation upgrade to EV/HEV platforms. The proposal of the paper is to present a collection of commented year back selected capacitor headlines that provides a great illustration about the recent directions in capacitor technologies by manufactures' press releases and pushed articles.

INTRODUCTION

This passive component dossier is aiming to illustrate the recent directions in capacitor and resistor technologies by summarising 2017 and 2018 (from May 17 to May 18) passive components news headlines that appeared on EPCI website (www.passive-components.eu) as a collection of Worldwide news.

TRENDS & OVERVIEW

The global passive component trend shows growing investments into development of new processes and materials to introduce completely new generation of passive devices. This includes also investments into manufacturing equipment and technological know-how.

MLCC SMD capacitor technology has been the leader in discrete passive components miniaturisation, where 0201 case size has been already in mass volume scale and smaller case sizes down to 008004 are step by step adopted by consumer electronics production nowadays. The sub 0201 and high CV components (>1000 dielectric layers per chip) commercialisation was conditioned by a generation move from thick film to thin film technologies.

Thin film is a higher development grade generation compare to thick film, but lower than semiconductor manufacturing technology. The semiconductor technology, however is by far more expensive. Thick film is considered to be cheaper but, on the other hand it is consuming more material that in some cases can result in opposite situation with favourable lower cost for thin film solution. In example, the 2017/18 resistor shortage has caused a high price increase of ruthenium resistive material influencing the chip resistors basic cost structure. MLCC capacitor continuously increase number of layers per chip to get higher capacitance in smaller package and offer the popular values in smaller (and cheaper) package. Thus, in general, we can expect a **continuous industry move towards the thin film technologies**.

The general recent trends in capacitor (and other passives) technologies can be summarised into the following directions:

- Integration into IC chips
- Embedding and Embroidering
- 3D structures
- New materials and Technologies

- Optimisation of mass volume technologies
- Harsh environment capable robust designs
- Range extension and Downsizing
- High power (lower ESR, ESL ...)
- New generation of thin film technologies for higher end applications
- Cost saving

Integration into IC chips

Longer term continuous trend is an integration of discrete passive components directly into the semiconductor chips. This process is driven by semiconductor technologies development and new circuit design architectures that can eliminate the need of discrete passive components – even at circuit position, where elimination of discrete components has been considered as impossible by now.

Embedding and Embroidering

Electronics miniaturisation calls for continuous component downsizing and new directions to get to the maximum performance in smallest package. Discrete passive components may occupy more than 70% of the PCB board space and thus they are on top of the list for downsizing, elimination or embedding into chips or PCBs.

Passive components **embedding** into PCB has moved from pre-production stage to mass consumer product usage for number of years. Nevertheless, the embedded technology still occupies only a fraction of the market with side interest for specific development by manufacturers at present stage. The “true” embedded discrete passive components offerings now include some MLCC capacitors and resistors from multiple vendors in 0.15mm max thickness versions, or other “embedded ready” components with max thickness below 0.6mm.

Fast development of wearable technologies in combination with growing popularity of IoT platform and medical monitoring functions have resulted in advancements of smart textile technologies and **embroidered** passive components. The technology is still in early demonstration phase mostly, nevertheless embroidered resistors, capacitors, antennas, inductors have been tested and proved to achieve satisfactory electrical and mechanical performance - within limited range of parameters. See [ref \[4\]](#).

3D structures and 3D passive components

3D manufacturing technologies are enabling new concept of 3D passive components design construction with features and performance that were unachievable by discrete passives until now.

One direction, represented by French based company IPDiA, a Murata group, is to utilise semiconductor technologies to produce passive components and its networks in 3D structure including bulk of the silicon wafer. Their patented 3D structure PICS technology can effectively combine tens to hundreds of capacitors, resistors, coils etc. on one chip saving up to 80% of space required.

The high density IPDiA 3D structures can be prepared down to 30µm thin, low weight MIS/MOS based layers. Capacitance volumetric efficiency reached 250 to 400nF/mm² in production, with demonstration up to 4µF/mm² in laboratory conditions. The components are robust to harsh environment in achievable operating temperature range -250 to 300°C. Operating voltage range is from 3 to 30V. The technology is ready for embedding and various passive integration methods.

The other direction under fast development is 3D printing of components by additive manufacturing processes using conductive and dielectric inks/substances. The 3D printing can be used for direct printing of discrete components or as a part of a system of whole 3D printed PCB. The capabilities have just been demonstrated in prototyping, but we can expect rapid development in this field. The technology may not be suited for high volume mass production, nevertheless it can bring a revolutionary design possibilities and ideas for specific low volume applications with unique electrical and mechanical properties. See example 3D PCB printer device and its capability at ref. [\[1\]](#), [\[2\]](#) and overview of aerosol jet printing capabilities [\[3\]](#). It can be also used as a fast prototyping proof of concept tool prior the mass volume production using conventional technologies.

New Materials and Technologies

Development of new materials and technologies to enhance component capabilities, range of parameters or reduce its cost is a general continuous improvement trend. One of the main approaches is to use less amount of “super, high tech materials” to replace bulk volume quantity of conventional materials. While the “super-material” is usually more expensive per weight or volume unit, the reduced consumption is still bringing cost saving at the same, or even better component features.

The recent headlines are documenting some new findings in the field of dielectric materials, as example of ceramic glass-barium titanate by EESore or General Atomics new dielectric materials that target high energy, high voltage up to 1kV and high temperature applications. Growing number of supercapacitors construction variants are providing new forms in stretchable, flexible, high energy, high voltage (3V) design supporting new ideas and applications.

Range Extension and Downsizing

See overview of some capacitors and resistors “World first” features and parameters enhancements released in 2017/18 such as the following highlights:

Capacitors

- Smaller DC link film capacitor
- 100kV film capacitors
- Film foil for temperatures up to 150C
- 1000uF MLCC capacitor 2.5V
- 10uF 100V 3525 MLCC capacitor
- Low ESR soft termination MLCC
- BME MLCC qualified to space
- 175/200C MLCC automotive
- World smallest 008004 MLCC capacitor
- C0G MLCC up to 200C
- 1000V 0603 C0G and X7R MLCC
- Tantalum polymer qualification at automotive or aerospace environment
- 30G vibration ready aluminium capacitors for automotive
- Glass to aluminium seal suggests Al El and Supercap reliability enhancement
- 85C 2000hrs and 85/85 1000hrs ready supercapacitors
- 3V (LiIon coin battery) ready thin supercapacitor
- Stretchable and flexible supercapacitors
- Up to 150C or down to -80C capable supercapacitor
- Reflowable chip supercapacitor
- Supercapacitor under space qualification

APPLICATION HIGHLIGHTS

Aerospace & Defence

Aerospace is going through a milestone transient change by privatisation of space business so far dominated by agencies and government orders. Commercial space projects for telecom satellites, broad internet access or space transport missions are representing more than 50% of space business today. This applies a high pressure on fast adoption of latest technology into space hardware and shortening of evaluation & qualification phase. COTS+ concept is under discussion. While radiation hardness is the key issue to address for active components, requirements for lead termination solder is the main barrier to adopt readily available commercial/automotive grade passive components “from stock”. [\[5\]](#), [\[6\]](#)

The latest manufacturer releases add **BME MLCC** technology to space qualified level [\[C10\]](#), while still extension of **PME MLCC** technology [\[C12\]](#) is going on. **Tantalum wet capacitors** are getting multisource at MIL level [\[C22\]](#). **Tantalum polymer capacitors** are step by step getting through qualification at space and automotive standards.[\[C25\]](#), [\[C26\]](#),[\[C27\]](#)

Aluminium capacitors with hermetical sealed package are trying to enter the defence and aerospace business claiming advantages (and lower cost) over tantalum capacitors [C32], [C33]. New glass to aluminium sealing developed by Schott is considered as a new potential to support this idea. [C30]

The recent evaluation and qualification activities includes utilisation of **supercapacitors** potential at space and harsh defence environment [C35], [C45]. Supercapacitor technologies already demonstrated its capability to operate up to 150C [C40],[C51], down to -80C temperatures [C54] or reflow-able chip package construction.[C41]

Automotive

Automotive industry is one of the most targeted application among the passive component development. The basic segmentation is cabin electronics (telematics, infotainment and entertainment, airbag + safety, communication, networking, etc.), under the hood (driving assistance, ABS, ESP, safety systems...), engine compartment (alternators, battery management, CPU, engine control sensors, inverters, start-stop system, etc.).

There are number of challenges and new development requirements related to the latest regulation and standard requirements (emission, safety.) and the upcoming new generation of EV and HEV vehicles with new specific requirements.

In the automotive and on-board automotive-related areas, the performance of equipment such as advanced driver assistance systems (ADASs) is progressing together with the advancement of space-saving mounting parts to ensure comfortable vehicle interiors. To this end, even individual passive components must conform to harsh environments (temperature range, vibrations, moisture), miniaturization and high-performance requirements.

The above requirements are causing some shift in component technology selection guidelines. **Film capacitors** are under pressure to be replaced on-board by **MLCC** due to size, life and temperature limitation. We can see some latest releases from film capacitor manufacturers [C3], [C5] towards higher temperature automotive grade products but still limited to 125C at high side, whereas the MLCC just released 175/200C automotive qualified range [C11], [C17] or specific humidity resistant series [C16].

Tantalum polymer capacitors [C25] are now available in automotive grade level capable to withstand 85/85 1000hrs life test and thus qualified to AECQ-200 requirements. New series of **automotive grade aluminium electrolytic capacitors** guarantee resistance to 30G vibrations.[C29]

Aluminium electrolytic capacitors with polymer electrolyte did not get a good reputation due to its DCL instability, the industry responded with new range of automotive ready “hybrid” electrolyte solution combining polymer and liquid electrolyte solution. The hybrid aluminium capacitors are now recommended as a superior lifetime and stable parameters option by manufacturers for wide range of automotive and industrial applications. [C34]

Industrial

Industrial electronics is a wide area of applications from a standard operation environment to the most demanding requirements for reliable components operations. Unlike automotive, where electronics is most of the lifetime in “off” state, or aerospace that after assembly, vibration launch the components are operating in non-humid, non-oxygen degradation environment, the industrial applications often require more than 10years 24h/7/365 days’ operation without defect at harsh conditions such as low/elevated temperature, high humidity, salt atmosphere etc.

The key passive component trends are downsizing, enabled by use of “super-materials” or “super-technology”, parameters range extension or reinforcement of robustness and life at harsh conditions.

This can be illustrated by the recent release of TDK smaller DC-link film capacitors [C2], extensions of max voltage range of Aerovox film capacitors up to 100kV [C4] or new 200/230C high temperature tantalum wet capacitors for oil drilling wells. [C24]

A specific topic of interest is generation, transportation, storage and harvesting of energy from nano-scale on chip solution up to high power energy applications. The top of interest is storage of energy for EV/HEV vehicles, recuperation, high energy power bank systems [C38], [C53] for renewable energy or power networking storage etc. The recent releases

include ruggedized [C35], high energy storage supercapacitors with record storage energy densities [C39], but also a development of new dielectric types for direct ~1kV voltage. [C13], [C14]

Medical

Medical cover wide range of requirements driven by its application fields. The basic segments are defined as follows:

- Life supporting (Yes-No)
- Implantable (Yes-No)
- Wearable (Yes-No)

The above segmentation is a key decision making factor for selection of proper passive components. In example - implantable, life support defibrillators are using tantalum wet capacitors with the highest energy density, while external AED devices rely on larger, but reliable film capacitors – as highlighted in Aerovox 2018 headline [C1]. Non-life supporting but high-reliability performance capacitor solutions can be represented by chip tantalum capacitors with improved reliability, lower DCL and small package.[C23]

Energy harvesting and powering of wearable electronics is enabled by the latest supercapacitors [C36], [C42], that can offer ultra slim design or in upcoming generation promise stretchable, flexible construction suitable for “smart” clothes implementation including wash resistance capability.[C43], [C46], [C48], [C49], [C52]

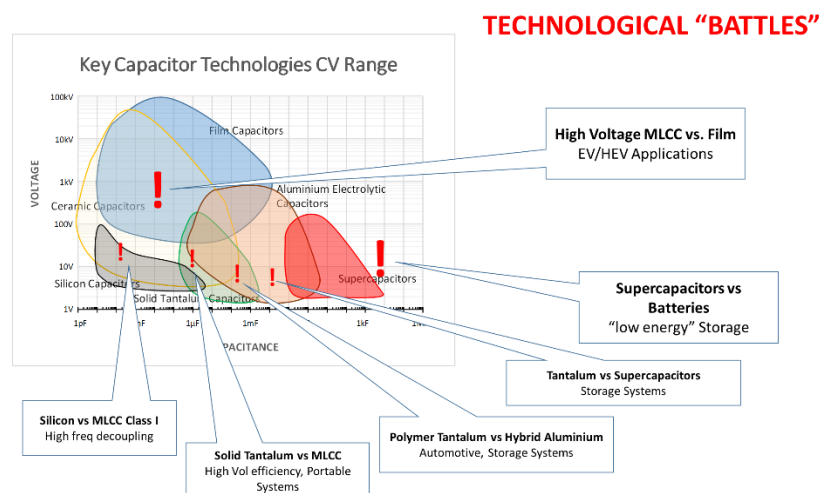
CAPACITOR NEWS HEADLINES

Capacitor Technologies

Capacitors are representing around 70% of all passive components and it gets most of circuit designers attention. In many cases, capacitors are used at power supply applications across the rail voltage and any eventual short circuit issue may lead to a critical failure to whole electronic design. As an energy reservoir, it can define end device operation life time or even enable some new applications.

There are number of capacitor technologies “battles” taking place at the moment, nevertheless we can identify about two key areas of a fast development and tight competition about the future dominance:

- 1) High Voltage MLCC and Film capacitors for EV/HEV Applications
- 2) Energy storage competition between batteries and supercapacitors



Let’s review capacitor technologies (5/2017 to 5/2018) key headlines to track its recent directions and specification upgrades:

1.1. Film Capacitors

- **[C1] 4/18 Aerovox Ships 3 Million Defibrillator Capacitors with Zero Field Failures.** Aerovox Corp., has shipped over 3 million lifesaving defibrillator capacitors with NO field failures. As modern defibrillators add more features and technology to their systems and, as they are used in harsher environments, the temperature range required for components to operate properly is increasing. Film capacitors perform much better at these higher temperature ranges compare to electrolytic capacitors. Defibrillators deliver high energy – 400 joules or more. Aerovox capacitors have a 2 joules per cubic centimeter capability (vs. 1 to 1.5 in competitive film offerings) which allows the device to be smaller, lighter and easier to handle. Film capacitors also have low leakage currents, and low dissipation losses, which ensures the delivery of the correct energy when the defibrillator is activated.
- **[C2] 3/18 TDK Film capacitors: Ultra-compact DC link solution.**
With dimensions of just 40 mm x 58 mm (d x l) it offers a rated voltage of 350 V DC and a capacitance of 65 μF . This means that the capacitor has a very high capacitance density of 0.9 $\mu\text{F}/\text{cm}^3$ and offers up to 50 percent more capacitance per volume than comparable capacitors. Other features include the low ESR of just 10 m Ω and the high ripple current capability of 3.7 A. The capacitor is designed for a temperature range from -25 °C to +65 °C. The capacitor has an integral thermal fuse that trips at a current of 5 A and a temperature of 115 °C.
- **[C3] 2/18 KEMET Announces New Automotive Grade Film Capacitors for Use in the Most Challenging Environments.** KEMET announced a new family of automotive grade metallized polypropylene film capacitors. F863 class X2 miniature capacitors are specifically designed to provide robust performance in safety applications in harsh environments and severe ambient conditions. These new devices provide across-the-line EMI and RFI filtering for the growing number of vehicle electronics applications, as well as in mains-connected indoor applications such as capacitive power supplies. The F863 series meets AEC-Q200 qualification requirements and is available in capacitance values ranging from 0.1 microfarads to 10 microfarads with rated voltages up to 310 VAC. The new, fully approved RFI X2 capacitors have an operating temperature range of -40 to +110 degrees Celsius.
- **[C4] 7/17 Aerovox Corp announces the development of a high voltage capacitor capability in excess of 100,000 volts for defense, industry and medicine.** Applications include marx generators, pulsed lasers, fusion research, particle accelerators, sources for medical imaging, military etc.
- **[C5] 7/17 Murata joint development of High Temperature Film Capacitor for automotive,** Murata has developed heat-resistant 450V film capacitors which can be used in a high-temperature environment of 125°C. These products are ideally suited for converters and motor drive inverters for environmentally friendly automobiles, or other applications requiring high-temperature performance and also have a reliable self-healing function. Because of this development, the new products can be used in a temperature zone where conventional film capacitors could not be previously used.
- **[C6] 6/17 SABIC'S New Dielectric Film for Professional Grade Film Capacitors.** SABIC is launching a new polyetherimide (PEI) film ULTEM™ UTF120 that exhibits stable properties through a range of temperatures (-40°C to +150°C) and frequency, including stable capacitance, good insulation resistance, high dielectric constant (Dk) and low dissipation factor (Df). The wide operating temperature capability of UTF120 based capacitors increases reliability and reduces or even eliminates the need for active cooling for converter applications.

1.2. Ceramic Capacitors

- **[C7] 5/18 TAIYO YUDEN Introduces the World's First 1,000 μF Multilayer Ceramic Capacitor.** TAIYO YUDEN CO., LTD. has announced today the mass-production of the “PMK432 BJ108MU-TE” (4.5 x 3.2 x 3.2 mm) product, which realizes a capacitance of 1,000 μF 2.5V for the first time in the world.
- **[C8] 4/18 TAIYO YUDEN Expands Its Product Line -up of 3225- Size Medium -to-High Voltage Capacitors.** TAIYO YUDEN announced medium-to-high voltage multilayer ceramic capacitor, 3.2 x 2.5 x 2.5 mm, with a capacitance of 10 μF and a rated voltage of 100 V. This product is suitable for input capacitors of DC-DC convertors in power supply circuits used in industrial equipment such as base station communication devices and servers. The sophisticated material technology TAIYO YUDEN has nurtured enables the product to achieve a capacitance of 10 μF , which is approximately twice as large as that of the company's conventional product.
- **[C9] 4/18 TDK introduces soft-termination MLCCs with low ESR.** TDK has developed the industry's first soft-termination MLCCs with low ESR. The new CN series features terminal electrodes with a conductive resin layer that provides high mechanical robustness to protect against board flexure. At the same time, the new MLCCs offer a low ESR that is comparable to that of conventional MLCCs. The CN series offers capacitance

values from 2.2 μF to 22 μF and rated voltages from 16 V to 100 V. Based on X7R dielectric material commercial grade and automotive grade types of the new MLCCs are available qualified to AEC-Q200.

- **[C10] 2/18 AVX is the First to Offer Space-Level X7R BME MLCCs Approved to MIL-PRF-32535.** The series delivers 39x increase in capacitance compared to 100V, 1812 MIL-PRF-123 & -55681 MLCCs — enabling revolutionary board space, weight, & component count reductions that directly translate into lower launch costs — & meets extremely stringent DLA requirements for high-reliability performance.
- **[C11] 1/18 Murata adds to lineup of lead type multilayer ceramic capacitors for automotive use at 175°C/200°C.** Murata has expanded the RHS Series of lead type multilayer ceramic capacitors for automotive use in high temperature applications. Products newly introduced include a 100Vdc rated product for 200°C use, which expands the previous lineup of 200Vdc and 500Vdc products, and a 100Vdc rated product for 175°C use with high capacitance. These products are primarily meant for use in equipment located in severe temperature environments such as the engine compartment of an automobile.
- **[C12] 1/18 AVX Extends its Space-Qualified ESCC QPL 3009 Series With New 200V X7R PME MLCCs.** The new 200V ESCC QPL 3009 PME MLCCs provide critical PCB space savings & component weight reductions over stacked ceramic capacitors & performance improvements over 100V MIL-PRF capacitors in mil/aero applications including: space launchers, satellite communications, & power supplies.
- **[C13] 1/18 General Atomics Develops Capacitor Tech for High-Voltage, High-Temperature Operations.** General Atomics' electromagnetic systems business unit has produced a capacitor technology designed to operate at high voltages and temperatures. The company said the new capacitor works to support stable operation of power electronics at more than 1000 volts and temperatures as high as 500 degrees Celsius. The new offering is meant to provide more stable behavior in varying temperature ranges over current capacitors. GA-EMS has successfully demonstrated pulsed power capacitors that offer record-breaking energy content of more than 415 kJ in a single capacitor, breaking previous records by more than 20%.
- **[C14] 1/18 EESor Announces Several Key Technological Improvements to Its Energy Storage Products.** EESor has developed several polar polymers for use with its composition modified barium titanate (CMBT) dielectric powder. The company's capacitors have the ability to store large amounts of energy, 19.04 Joules/cubic centimeter (J/cc) or 5.2 watt hours/liter (wh/l). Testing have shown EESor's glass-CMBT to be a relaxor dielectric with a relative permittivity over 30,000. Key features of EESor's relaxor include a high relative permittivity and low residual polarization, giving EESor's dielectric the ability to both store higher amounts of energy during charging and, unlike non-relaxor barium titanate, return most of that energy during discharge. Additionally, the tested layers relative permittivity is shown to stay above 10,000 at a field of over 1 volt per micron. This permittivity rivals, and in most cases, surpasses that of, lead based relaxors.
- **[C15] 12/17 KYOCERA Develops Some of World's Smallest Multilayer Ceramic Capacitors for Mobile Devices.** Kyocera announced new MLCCs for mobile device applications in a 008004 case size, among the world's smallest*1. Measuring just 0.25 x 0.125 x 0.125mm, Kyocera's new CM01 Series MLCCs reduce space requirements by 60% in surface area and 75% in total volume as compared to conventional products. Capacitance value is from 0.2 to 22pF at 25 and 16V rated voltage.
- **[C16] 10/17 Murata's water repellent MLCC capacitor for car infotainment systems.** Murata has introduced GXT water repellent capacitors for automobile infotainment systems and comfort equipment. Designed with a water repellent layer on a multilayer ceramic capacitor, the product conforms to the AEC-Q200*1 electrical parts standard for automotive applications.
- **[C17] 9/17 KEMET Introduces C0G High Temperature 200 Degree Celsius Bulk Capacitance Solution for Harsh Environment Applications.** The C0G/NPO BME capacitors are ideal for demanding high temperature, high voltage and high vibration applications such as down-hole oil exploration, automotive and hybrid electric vehicles (HEV), defense and aerospace. Available in 3 case sizes, the KPS-MCC series offers voltages up to 2 KV and capacitance up to 2 microfarads in a footprint of less than 0.55 square inches. Each case size can be ordered in a straight pin, formed "L," or formed "J" configuration and with a silver (Ag) or solder coated (SnPb) termination finish.
- **[C18] 8/17 Vishay RF MLCCs Offer Reliability and Design Flexibility With Industry's First Operating Temps to +200 °C in Small Cases** For telecom base stations and military communication systems, the Vishay HT series provides ultra high Q and low ESR in case sizes 0402, 0603, 0805, and 1111.
- **[C19] 7/17 KEMET - Expand High Voltage Multilayer Ceramic Capacitor Portfolio** by 0603 1000V C0G and X7R MLCC Capacitor
- **[C20] 7/17 Murata chief sees plenty of room for growth** in smartphone we see a dramatic increase in the number of electronic parts used in a single device. Take capacitors, for example. Whereas ordinary phones use

100-200 of them, high-end smartphones have 800. Automakers are competing to introduce functions using onboard sensors, such as automatic braking and parking assistance, and this has increased demand for electronic parts. Our auto-related business has grown 10% annually, but the rate of growth is accelerating, so this segment is finally really taking off.

- **[C21] 7/17 Knowles – New range of high temperature MLC chip capacitors significantly extended** to -55C to +200C. Launch specifications encompassed both C0G and X7R options in case sizes 0805 to 2220, 4.7pF to 3.3uF and 16VDC to 630VDC.

1.3. Tantalum Capacitors

- **[C22] 4/18 Exxelia Introduces the DSCC 93026 family of Wet Tantalum Capacitors.** Exxelia has received the qualification by the DSCC under the drawing DSCC 93026. The voltage range is from 25V up to 125V and capacitance values from 10μF up to 1800μF with operating temperatures of -55°C to 125°C. The series is ideal for use in high-reliability defense, avionics, radars and power supply applications requiring high capacitance or high energy storage.
- **[C23] 2/18 New AVX T4Z Medical Series HRC4000 Tantalum Capacitors for Non-Critical Medical Devices.** Manufactured in compliance with strict FDA regulations, the T4Z Medical Series delivers consistent, high-reliability performance with the lowest DCL values in the market (0.01CV down to 0.005CV) & offers short, stable lead-times extending to a maximum of eight weeks, providing an ideal alternative to commercial capacitors.
- **[C24] 1/18 Vishay HI-TMP® Wet Tantalum Capacitors Offer Increased Reliability for Industrial and Oil Exploration Applications** Vishay today introduced a new series of HI-TMP® tantalum-cased, hermetically sealed wet tantalum capacitors with high temperature operation to +200 °C. Offering increased reliability for industrial and oil exploration applications, T34 series axial-leaded through-hole devices deliver increased mechanical shock and vibration withstand ability, along with longer life.
- **[C25] 7/17 KEMET Broadens Automotive Applications Where the Benefits of Polymer Electrolytics Can Be Utilized** The addition of 35V devices for capacitance values of 22 and 33 microfarads represents a first-to-market for KEMET. The new AEC-Q200 qualified parts extend the range of automotive applications in which the benefits of polymer electrolytic devices can be utilized, and provide a product capable of meeting voltage transient critical requirements.
- **[C26] 6/17 KEMET Enhances its Hi-Rel COTS KO-CAP® Polymer Electrolytic Device Offering with Extended Life Test Option** KEMET has introduced the industry's first COTS grade polymer electrolytic capacitor with a 1,000-hour life test option. The new option, also known as the "Biased Humidity Test," provides capacitors qualified at 85 degrees Celsius with 85% relative humidity at rated voltage applied for 1,000 hours. The test type provides capacitors qualified to the rigors of MIL-STD-202 Method 103.
- **[C27] 6/17 Kemet makes space-grade polymer electrolytic capacitors in Europe** A detail specification was released by ESCC (3012/005) and the T583 series complies with its requirements.
- **[C28] 5/17 AVX Doubles the Lifetime of Select THH 230 degrees C Hermetic Series High Temperature SMD Tantalum Capacitors.** AVX's THH Series now offers 2,000-hour extended lifetimes at 230 degrees C on selected ratings & robust mechanical shock & vibration resistance at 230 degrees C compliant with MIL-STD-202 on all ratings.

1.4. Aluminium Capacitors

- **[C29] 12/17 Panasonic Commercializes an Automotive, High Vibration Acceleration-Resistant, Conductive-Polymer Hybrid Aluminum Electrolytic Capacitor.** The capacitor is the industry's first 6.3mm diameter and 30G vibration acceleration resistant characteristics. The anti-vibration, surface-mounted conductive-polymer hybrid aluminum electrolytic capacitor is suitable for use in power circuits for automotive electric control units (ECUs) employed in hybrid electric vehicles, electric vehicles, and gasoline-powered vehicles.
- **[C30] 10/17 World's First Glass-to-Aluminium Seal: SCHOTT's New Lid Technology Boosts Capacitor Performance.** SCHOTT has developed a pioneering solution to mitigate electrolyte dry-out in capacitors for long-term and reliable high-level performance. New leak-tight lid technology will open a wealth of design opportunities for leak-tight aluminium capacitors and supercapacitors enabling higher capacitance, longer life time and temperature resistance.

- **[C31] 6/17 Nichicon and SBE Announce Initial Partnership to Develop Hybrid DC Link Capacitor Banks**
By tailoring the impedance of the extremely low ESL/ESR Power Ring and the specifically characterized Aluminum Electrolytic Capacitor bank system, the result is a very high current density DC Link that also has space efficient energy storage capabilities. Such systems are a highly desired part of the newly emerging SiC and GaN converters for next generation systems and advanced high voltage/high efficiency Si systems for utility and alternative energy applications.
- **[C32] 6/17 Cornell Dubilier's New Flatpack Aluminum Electrolytic Capacitor Suit Military and Space Needs**
Hermetically-sealed electrolytic capacitors feature a better retention at low temperatures compared to wet tantalum capacitors. With an ultra-long lifespan, the ability to handle 80g's of vibration, the technology could replace banks of wet tantalum capacitors. One aluminum electrolytic capacitor takes the place of three or four wet tantalums to provide the same capacitance at low temperature.
- **[C33] 6/17 Cornell Dubilier Ruggedized Axial-Leaded Aluminum Electrolytic Capacitor Performs to +175 °C without Derating.**
The CDE HHT Series is the only aluminum electrolytic capacitor available in the market with +175 °C performance. This is usually the domain of the considerably more expensive wet tantalum technology. The HHT's glass-to-metal seal is the reason. With capacitance stability at high temperature, low leakage current and very competitive ESR and ripple current specifications, these devices provide new options for mission-critical applications.
- **[C34] 4/17 Panasonic launches new Hybrid Capacitors line.**
Hybrid Capacitors combining the advantages of electrolytic capacitors with those of solid Polymer Capacitors, have established themselves as reliable and versatile solutions in automotive and industrial applications alike. Hybrid technology offers low leakage current and long life in combination with low ESR (20mΩ) in miniature case sizes. The surface-mount conductive Polymer Hybrid components offer a nominal capacitance range of 33μF up to 330μF, at voltage ranges from 25VDC up to 63VDC, and feature an operating temperature range of -55°C up to 145°C, as well as low ESR and high ripple current. The products are AEC-Q200 compliant, can endure high humidity conditions rated at 85°C/90% – 2,000h while offering tiered ripple current ratings at 135°C and 145°C.

1.5. Supercapacitors

- **[C35] 5/18 Vishay Launches New Ruggedized ENYCAP™ EDLC Energy Storage Capacitors for Long Life and High Moisture Resistance.**
new series of ruggedized ENYCAP™ electrical double-layer energy storage capacitors for energy harvesting and power backup applications in harsh, high humidity environments. Vishay BCcomponents 225 EDLC-R ENYCAP capacitors are the industry's first to offer useful life of 2000 hours at +85 °C and meet the highest class of moisture resistance: the biased 85 / 85 1000-hour test
- **[C36] 4/18 CAP-XX Develops Industry's First 3 Volt Thin Prismatic Supercapacitors.**
CAP-XX announced it has developed the industry's first 3V thin, prismatic supercapacitors. It provides peak power support to 3V coin cell batteries and eliminates need for 2.7V LDO regulator for less expensive, smaller, more energy-efficient designs with extended battery life.
- **[C37] 3/18 Eaton announces 3.0-volt XT supercapacitor for increased high-power, high-energy applications.**
Eaton announced its new 3.0-volt XT supercapacitor that offers 15 percent higher energy density and 20 percent higher power density at a lower cost per watt-hour versus currently available supercapacitors. The new supercapacitor allows a reduced size and weight for high cell count designs.
- **[C38] 3/18 Skeleton Launches Laser-Welded Ultracapacitor Packs to Boost Logistics and Energy Sectors.**
Skeleton Technologies has launched SkelPack, the laser welding service to create ultracapacitor packs allowing the most complex designs and providing much higher reliability and durability compared to bolted ultracapacitor pack layouts.
- **[C39] 3/18 Rolls-Royce links up with UK-based Superdielectrics to explore potential of very high energy storage technology.**
Superdielectrics Ltd is a material research company that has discovered, an entirely new group of polymeric superdielectrics. The Company is commercialising this very significant scientific breakthrough in supercapacitor electrolyte materials and electrical energy storage. The University of Bristol estimates that these newly discovered materials have dielectric property values which are 1,000-10,000 times greater than conventional electrolyte solutions. This breakthrough offers the prospect of a new energy storage technology that is superior to existing battery technology.
- **[C40] 2/18 FastCAP Ultracapacitor for Extreme Environment Applications.**
FastCap has created a unique ultracapacitor utilizing carbon nanotubes and a unique electrolyte that extends the temperature range beyond other capacitors, allowing for use in extreme environments from -55 to +100degC and -40 to +150degC operation ranges.

- **[C41] FastCAP Reflowable Chip Ultracapacitor for Power Backup.** FastCAP's chip ultracapacitor is claiming to become the first reflowable, slim profile, and low ESR device that fits energy storage requirements for power back up and power loss protection in SSDs.
- **[C42] 1/18 CAP-XX Thinline Supercapacitors Power Vibration Alerts.** Thinline supercapacitors into the new Spire Health Tag to provide the peak power needed for delivering real-time wellness vibration alerts to consumers. Offloading this peak power role to the thin, flat supercapacitor allows Spire to keep the battery small to achieve the ultra-thin form factor of its new wearable fitness biosensor that attaches to clothes once, can be washed as normal, and needs no charging.
- **[C43] 12/17 All-Nanotube Stretchable Supercapacitor With Low Equivalent Series Resistance.** Skoltech and Aalto University (Finland) proposed a novel method for the fabrication of an all-nanotube stretchable supercapacitor from SWCNTs film electrodes and BNNTs separator. The BNNT separator of only 0.5 μm thickness ensured reliable short circuit protection and low equivalent series resistance (ESR) of the stretchable supercapacitor (SSC). The device retains 96 percent of its initial capacitance after 20 000 charging/discharging cycles with low equivalent series resistance of 4.6 Ω . The stretchable supercapacitor prototype withstands at least 1000 cycles of 50 percent strain. With its stable performance, the device could act as a promising candidate for wearable electronic devices and flexible energy storage systems
- **[C44] 11/17 Lamborghini moved away from standard batteries and focused on supercapacitors** at their Terzo Millennio concept. Lamborghini currently uses supercapacitors to power the stop-start system of the Aventador. Lamborghini and MIT are researching using the car's carbon fiber body as an energy storage medium, turning the whole body into a battery of sorts.
- **[C45] 11/17 FastCAP Systems shoots for space with latest funding.** FastCAP Systems raised over \$2 million as it creates a new division aimed at using its technology for space exploration. FastCAP Aerospace Technologies will also be based out of Boston. FastCAP is known for its ultracapacitor technology, which makes it possible for batteries to have extremely long lifespans. The batteries are used specifically in oil, gas and geothermal drilling, but it's also working on using the technology in consumer vehicles and aeronautics — both for commercial and military use. FastCAP's batteries currently hold five world records, including for one for highest operating temperature, another for highest power and yet another for highest energy, according to FastCAP.
- **[C46] 10/17 Flexible paper-based supercapacitor with metal nanoparticles.** Using a simple layer-by-layer coating technique, researchers from the U.S. and Korea have developed a paper-based flexible supercapacitor that could be used to help power wearable devices. The device uses metallic nanoparticles to coat cellulose fibres in the paper, creating supercapacitor electrodes with high energy and power densities — and the best performance so far in a textile-based supercapacitor. Devices fabricated with the technique can be folded thousands of times without affecting conductivity.
- **[C47] 9/17 Solid-State, Free-Standing Carbon Nanofiber Supercapacitor.** Drexel University have created a fabric-like material electrode that could help make energy storage devices—batteries and supercapacitors—faster and less susceptible to leaks or disastrous meltdowns. Their design for a new supercapacitor, which looks something like a furry sponge infused with gelatin, offers a unique alternative to the flammable electrolyte solution that is a common component in these devices.
- **[C48] 8/17 Candy cane supercapacitor could enable fast charging of mobile phone** - The technique could be applied to many types of materials for supercapacitors and enable fast charging of mobile phones, smart clothes and implantable devices. This interpenetrating structure enables the material to bend more easily, as well as swell and shrink without cracking, leading to greater longevity.
- **[C49] 8/17 CAP-XX rises on largest-ever order for supercapacitors** CAP-XX received its largest-ever order for Thinline supercapacitors. A US customer has ordered the supercapacitors for an 'Internet of Things' (IoT) wearable device for the fitness and health markets
- **[C50] 7/17 Fraikin Harnessing the Power of KERS with Skeleton Technologies' Ultracapacitors** - announced the first installation of a Kinetic Energy Recovery System (KERS) in a rigid truck – a 12-tonne Iveco Eurocargo. The KERS system works by harnessing the energy created under braking. This energy is stored in a set of SkelCap ultracapacitors – then used to provide acceleration assistance via an electric motor fitted to the prop shaft. The KERS system offered 32 per cent fuel savings, slashing nitrogen oxide emissions by around 50 per cent and carbon dioxide emissions by around 30 per cent.
- **[C51] 7/17 Yunasko Ultracaps Operating at 100C Enable new Applications** Test results confirmed the stable performance of YUNASKO high-temperature ultracapacitors that successfully passed endurance tests at +100°C for 2,000 hours, which normally corresponds to the cycle life as long as million of charge-discharge cycles

- **[C52] 7/17 Superstretchable, Supercompressible Supercapacitors** Chinese scientists have introduced an extraordinarily stretchable and compressible polyelectrolyte which, in combination with carbon nanotube composite paper electrodes, forms a supercapacitor that can be stretched to 1000 percent in length and compressed to 50 percent in thickness with even gaining, not losing capacity
- **[C53] 6/17 Supercapacitors could be better than batteries or fuel cells for clean electric powered transit** China Railway has built a light rail system using supercaps that can be fully charged in a 30 second stop and then run three to five kilometres to the next stop. 85 percent of the energy generated from braking the train is returned to the capacitors. It can travel at 70 km/h and hold 380 passengers.
- **[C54] 6/17 Electrolytes made from liquefied gas enable supercapacitors and batteries to run at ultra-low temperatures.** The new electrolytes enable electrochemical capacitors to run as low as -80 degrees Celsius, while high performance at room temperature is still maintained. The new electrolyte chemistry could also increase the energy density and improve the safety of lithium batteries and electrochemical capacitors.

SUMMARY AND CONCLUSION

Capacitors are one of the critical components needed for any electronic hardware designs. We are living in a challenging time with several end market changes and new technology developments on both component and end application sides. Some of the latest trends in capacitor technology and end application market has been demonstrated in this paper using a 2017/2018 capacitor news headlines.

In short summary, the current and future capacitor challenges are related to its core function – energy storage. Generation, recuperation, transportation, transmission and storage of energy from nano-scale up to high power storage networks are among the key topics for today's electronic and even human society evolution.... from wearable energy harvesters, through electric vehicles to handling of energy generated by renewable sources.

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