Polymer Aluminum Capacitors

World Markets, Technologies & Opportunities: 2012-2017

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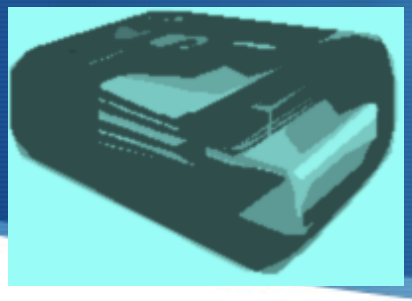

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Scope of Coverage:

This study addresses the global market for conductive polymer aluminum electrolytic capacitors in molded chip, vertical chip and radial leaded configurations. The components are known for their high capacitance, broad voltage range, and volumetric efficiency, but what really separates conductive polymer aluminum capacitors from conventional electrolytic designs is their low equivalent series resistance (ESR). Conductive polymer aluminum capacitors compete against tantalum polymer capacitors and niobium polymer capacitors in the surface mount configuration. Conductive polymer aluminum capacitors in the vertical chip and radial leaded configurations only compete against other aluminum capacitors that employ traditional liquid electrolytes and that do not have low ESR.

Reason For The Report:

Conductive polymer aluminum capacitors have been the focal point of electrochemical capacitor technology for more than ten years. The application of a conductive polymer in the finished capacitor creates a component with extremely low equivalent series resistance that is also resistant to catastrophic failure. More importantly, in its molded ship configuration, the solid polymer aluminum capacitor is a viable alternative to tantalum chip capacitors, which have been plagued with supply chain problems due to the "conflict" nature of the tantalum ore supply chain. The shortcomings of the solid polymer aluminum capacitor market is that the capacity to produce solid polymer aluminum capacitors remains limited, and the breadth and depth of the available product portfolio with respect to capacitance values, voltage ratings and case sizes is limited when compared to that of tantalum capacitors.

Background of The Report:

Historical Development of Polymer Aluminum Capacitors:

Conductive polymer usage in electrolytic capacitors on a mass scale has been well documented and began with its usage in tantalum capacitors. The tantalum polymer chip capacitor, known as the NEOCapacitor®, was developed by NEC Tantalum Corporation in 1995 (now NEC-Tokin Corporation, which announced in 2012 that it would become part of Kemet Corporation USA) using an anode dipping method. At the same time, Sanyo Video Components, also a Japan corporation had developed polymer tantalum capacitors using a different technical approach (a gas infusion process). In fact, in a 1995 interview of IBM Corporation by Paumanok it was learned that Sanyo was their preferred supplier for decoupling the Pentium Processor and they also noted that Sanyo was instrumental

in the development of the OS-CON aluminum capacitor, which was based upon a radial leaded aluminum electrolytic capacitor design that used a complex salt structure known as isoquinolinium to usable voltage, high capacitance design with very low ESR. It was from these early developments in tantalum ands aluminum that eventually gave rise to the use of conductive polymers as cathode materials in molded chip, vertical chip and radial leaded aluminum dielectric capacitors.

Sanyo and NEC, for example, were also quick to note the potential to displace the manganese nitrate used for coating tantalum anodes with conductive polymer. Pyrole was chosen and this polymer was polymerized and pressurized as a "skin" into the nodules that make up the surface area of a tantalum anode. ESR dropped dramatically by the use of polypyrrole in solid electrolytic chip capacitors, which proved critical in decoupling high frequency microprocessors in multiple applications that Kemet soon licensed the NEOCapacitor as the KO Capacitor for distribution in the west, and Kemet began their own study of electro conductive polymers, especially in polythiophene, a material invented by Bayer Corp's HC Starck subsidiary. The material, which was sold under the tradename Baytown, was sold along with other polymer products to Hereuas, which manufactures and markets the material to the capacitor industry today. Polythiophene materials are consumed in capacitors that require higher operating temperatures to 125 degrees C.

Meanwhile, back in Japan, Matsushita Electric Industrial Circuit Capacitor Division (now Panasonic Electronic Devices) developed the D Case polymer aluminum molded chip SP-Cap, which offered excellent ESR in a molded chip package with the use of crimped aluminum anode covered in a skin of organic polypyrrole as the cathode. This cathode skin replaced the traditional aluminum foil cathode in a package that was similar in size and shape to the best selling tantalum capacitors. Between 1995 and today multiple vendors have introduced capacitors with conductive polymer as the cathode. The large volumes of consumption are in the molded and coated tantalum chip capacitors, horizontal molded aluminum chip capacitors, vertical chip aluminum capacitors and radial leaded aluminum capacitors.

Additional development work is underway for the use of conductive polymers in electric double layer carbon capacitors, and additional development is underway for the use of polymer cathodes in niobium capacitors as well.

Why Lower The ESR In A Capacitor?

ESR is an industry buzzword- it means equivalent series resistance and the lower the ESR the better. Single digit ESR is the near term target and ESR ratings less than 1 are envisioned by the customer. By lowering the ESR, the speed by which the capacitor can release its charge is increased.

The Different Types of Conductive Polymers Employed In Capacitor Cathodes:

There are three conductive polymers currently in use as cathode materials in the capacitor industry. These include polyppyrole, polythiophene and Polyaniline and multiple derivations thereof. Two additional conductive polymers exist although Paumanok notes no known usage of these additional conductive polymers outside of the electroluminescent display markets. Polyppyrole is the polymer that has the largest usage across both tantalum and aluminum capacitor markets and is the most heavily consumed worldwide, however, polythiophene is becoming a larger part of the growing market, while polyaniline is being used in addition to the other polymers for unique purposes (as a sealer material in conjunction with polythiophene) that enhance the performance of the finished anode.

The Difference in Conductive Polymer Performance In The Finished Capacitor:

Paumanok has determined that while each of the conductive polymers have different prices, with polypyrrole being the least expensive and polyaniline being the most expensive, that there is no difference in performance of any of the polymers. All three offer very similar ESR performance in the finished capacitor. Capacitor vendors however, have varying ESR ratings that are disproportional to the limited number of conductive polymers to choose from, which means that other aspects of the production process are key to lowering the ESR (This is important to understanding the dynamics of the market).

Variations on Construction and Capacitor Configuration:

What is interesting in the industry is that conductive polymer technology is replacing traditional cathodes in three separate product configurations currently on the market. Therefore we find conductive polymer cathodes in molded chip capacitors (tantalum chip, aluminum chip and niobium oxide chip- with the primary market overlap between all three products in the D case size (EIA designated case size). These three dielectrics form the core of growth for the future foundation of the electrolytic chip capacitor for digital electronics. These three dielectrics are also produced in solid format, which tells the consumer that no liquid is contained in the capacitor for safety reasons. Also, the solid polymer aluminum capacitor is produced in the V-chip, or vertical format. There is also the radial leaded aluminum capacitor market which is consuming liquid + conductive polymer, which is also growing because of

safety concerns surrounding radial leaded capacitors with conventional liquid electrolytes. Radial leaded capacitors with liquid + polymer electrolytes operate at a higher frequency range when compared to solid polymer capacitors (The focus of this report is on polymer aluminum capacitors, but it is important for the reader to understand the keen relationship between tantalum capacitors and aluminum capacitors that contain polymers, not only from a technical perspective but from a perspective of competition between the two dielectrics as well).

Key End-Use Markets For Conductive Polymer Aluminum Capacitors:

Based upon primary discussions with vendors and a careful analysis of all available literature on the subject, consumption of solid polymer capacitors differs somewhat from the consumption of the larger electrolytic capacitor markets. The major customers for conductive polymer aluminum capacitors are primarily in Taiwan and China and are associated with computer motherboard, power supply and video graphics card production. Other major consumers are in the game console market where conductive polymer capacitors are consumed in increasingly larger volumes. Another large market is the Japanese digital still camera and digital video camera markets; as well as for driver information electronics in high-end automobiles. For the vertical chip and the radial leaded parts we see applications not only in the desktop computer markets, but also for applications in flat panel displays, which is the second largest market for conductive polymer aluminum capacitors to computers (The reader should also understand that both the computer market and the flat panel display markets have their production centered in greater China, with a keen focus in Taiwan; and this explains why there has been such a large increase in production capacity for conductive polymer aluminum capacitors in China in the past few years).

Competitive Nature of The Industry:

Since the number of available polymers for use in capacitors is limited and the number of vendors selling conductive polymer capacitorsd is comparably large, plus the fact that among these capacitor manufacturers their respective ESR capabilities vary by so very much, the logical conclusion is that processing **differentiation** between vendors is also key. For example, the best ESR will be found in the capacitor that has the most consistent coverage of the capacitor anode. This has been attempted by a gas diffusion process and a traditional cathode dipping process. ESR can further be improved by the type of capacitor grade aluminum foil used, as well as the packaging of the finished capacitor.

Market Potential and Growth:

The low ESR market continues to be one of the fastest growth portions of the global capacitor industry as design engineers give increasing importance to ESR in addition to voltage, capacitance, operating temperature and price when buying electrolytic capacitors. Although price continues to be the most important criteria of negotiation regardless of how fast the capacitor releases its charge. As for the vendors of conductive polymers selling to capacitor vendors, these plastics producers will continue to grow at a rate in accordance with the market, and have the entire manganese nitrate market to take over in tantalum, and the entire wet electrolyte market to take over in aluminum. Also, because of the well documented problems with the supply chain for tantalum, especvially since US government legislation has determined tantalum to be a "conflict" material, the molded chip polymer aluminum capacitor has a very real ability to take over an increasingly larger portion of the tantalum capacitor market in the future. This is supported by the fact that aluminum is in abundant supply and does not have any of the supply chain problems noted in tantalum and its tantalite precursors.

Conductive Polymer Aluminum (Al203) Capacitors:

Horizontal Molded Chip Polymer Aluminum Capacitors (H-Chip) :

The horizontal aluminum electrolytic capacitor market represents a molded chip technology with aluminum anode that is designed in terms of capacitance, voltage, ESR and case size to compete against polymer tantalum capacitors. Market growth has been prohibited due to high pricing (2X that of a V-chip aluminum design) and a limited number of vendors, although in 2012 the market seems poised for additional growth as the tantalum supply chain becomes more precarious. Intended markets match that of **large case size** tantalum capacitors and therefore, these devices can be found in computers, automotive electronics and related markets. This market will experience growth in 2013, continuing through 2017 and beyond.

Almnost all molded chip polymer aluminum capacitors come in the standard D case size chip format (an Electronic Industries Alliance USA designation) at this time. In the past two years we have noted that Panasonic has also developed a C case size molded chip, which is a very important development to expand the molded polymer chip aluminum capacitor market. The reason why the larger case size tantalum chip capacitors are important target markets for molded polymer aluminum chips is that the larger case size tantalum chips consumed more tantalum raw material (powder and wire) per anode than other case sizes and are more vurnerable to displacement by alternative technologies as a result. They also have a high price point as a