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Conference Report

Fixed capacitors represent the biggest passive component market, and because of this it was interesting to have a seminar devoted to them. The meeting was organized by ERA Technology Ltd., in London in September 1980, with the emphasis on small capacitors. Over 100 delegates attended and there was an exhibition associated with the seminar.

Four main areas were covered, namely metallized film, ceramic, aluminium electrolytics and energy storage capacitors.

In the first session, polyester, polypropylene and polycarbonate devices were considered. Stewart and Righton from Ashcroft Electronics discussed aluminium metallized miniature capacitors and compared polypropylene, polyester and polycarbonate. Polypropylene has the lowest loss, polyester can be obtained in the thinnest sheets and therefore gives the best space utilization and polycarbonate has the lowest temperature coefficient of capacitance (±50 ppm/°C.) together with the highest temperature of operation. Methods of encapsulation and quality control have been improved over the last decade for all these types to give devices that are now smaller and more electrically stable than ten years ago. The authors noted that problems in the development of auto insertion equipment for radial-lead components have now been largely solved, especially for the smaller types and this gives these capacitors a firm future.

Mr. Hollands of Plessey Capacitors, considered the quality control necessary to give reliable polyester devices whether for a benign or hostile environment and discussed design criteria, goods inward inspection, in process testing and the QA required. Both the first two papers also raised the question of the Japanese quality assurance philosophy and noted how low defect levels are achieved by a very close working relationship between vendor and customer in examining defective capacitors, as well as effective in-process testing. It was noted that at least one U.K. manufacturer is in the same target area of quality on polyester capacitors as the Japanese, and developments currently in progress should result in even lower defect levels.

Mr. Berge from RIFA, Sweden, in the final paper on metallized film capacitors, examined low cost polypropylene capacitors (0.01% tan δ), and discussed capacitors, made with metallized film as thin as 4 μm. However, most devices since 1972 have been made with either 8 μm or 10 μm material. Polypropylene has excellent self healing properties, high humidity resistance provided aluminium metallization is used and not zinc, and, provided the capacitors are made in a clean environment, low loss due to the few free dipoles in the plastic film. The dielectric strength is better than other plastics at 200 V/μm at 250°C, but the dielectric strength is not proportional to thickness. Other factors such as the frequency limitation (less than 1 MHz), dielectric absorption (less than 0.01%), stability (less than 0.1% change after over three years at less than 50°C, with a relative humidity of less than 70%), current carrying ability and corona discharge starting voltage (400V rms at 50 Hz 0.01 μF) were discussed. Finally an outline was given of suitable applications in precision, pulse, thyristor commutation, discharge and motor use.

The biggest growth in the fixed capacitor market has been shown by multilayer ceramic capacitors, mainly due to the fact that they are now so widely used in the rapidly expanding field of microelectronics. Two papers were given in this area. The first by Nicker of ITT Components gave an able review of the preparation and properties of multilayer structures based on the titanates and with electrodes of platinum or gold and palladium. Over the last 10 years different electrodes – pure palladium, sometimes with the addition of silver, have been developed in conjunction with ceramic formulations that allow of their use with such electrodes. Work is continuing on reducing the cost of capacitors, and various areas were considered such as further improved electrodes – silver or base metals, impregnated structures in which electrodes which are removed in the initial sintering are used, so enabling the slots in the body to be filled with a solder based material when impregnated in vacuum at low temperatures, and different ceramics such as recrystallized glass (k up to 800). Also the use of boundary or barrier layer dielectrics based on barium or strontium titanate was discussed. Barium titanate can give high k dielectrics (up to 100,000), but the material is very poor in temperature stability (due to the curie temperature of barium titanate being 120°C). Strontium titanate has better temperature behaviour but with a lower k (75,000).

The electrical properties of multilayer ceramic capacitors based on barium titanate were discussed in detail by Siddle of Tekelec Components with regard to temperature coefficient of capacitance, DC voltage effects both in terms of the voltage coefficient of capacitance and the dielectric strength, AC effects from 50 Hz to 10 KHz, tan δ, insulation resistance and ageing. The paper reviewed these effects in relationship to polarization in the ceramic.

A research paper on glass/ceramic capacitors for high voltage and energy storage applications was given by Hill and Worrell of ERA. Glass ceramics are formed by controlled devitrification of a glass body by the use of nucleation agents, and as a result has grain sizes much smaller than those obtained with conventional ceramics. Ba, Sr and Pb niobates recrystallized from Al-B-silicate glasses have been studied. The mix is band cast to give layers 50 μm thick, and then stacked in the green state, heated in order to remove the organic binders, and finally sintered. Electrodes of gold, silver and silver-palladium have been used, with 70% Ag; 30% Pb proving the most successful. Electrical strengths of up to 44 V/μm with a material of permittivity 116, tan δ = 1.3% and stored energy of 0.1 MJ/m^3 has been obtained. Higher permittivity values were obtained with other compositions (ϵ = 1200) giving 0.38 MJ/m^3, but the strength was slightly reduced (28V/μm), and the loss increased (5.2%).

Aluminium electrolytic capacitors were discussed in two papers, one by Gregson of ITT Components and the other by Clarke of Sprague. Advances in the last 10 years were outlined by Gregson. They have been in the areas of electrolytes for high temperatures (greater than 70°C), the paper tissue where a decrease in electrolyte resistance factor from 11–40 to 2–20 has been achieved, the use of cold welding technology for attaching leads and improvements to the manufacturing process, particularly with regard to heat ageing. The general trend towards high frequency operation as in switching mode power supplies was discussed by Clarke.

The ageing mechanism in high voltage energy storage capacitors was considered by Hayworth (CSI Capacitors, USA), Warrilow and Weil (Hartley Measurements UK), for paper, mylar-paper, polypropylene and "k-film" devices. These were shown to be the DC life, which is a function of the total exposure of the capacitor to a high voltage, and the shot life, which depends on the total number of charge-discharge cycles taken from the capacitor. These mechanisms are independent of one another but are both affected by factors such as the voltage reversal in the discharge cycle, and also operating temperature. From the considerations of these factors, together with others, such as peak current requirements and inductance, it was shown how specifications could be evolved to cover a wide variety of applications in equipment such as cardiac defibrillators, lasers, detonator systems and photocopiers.

The use of polyvinyldene fluoride (PVdF) and also of biaxially orientated polypropylene in lightweight energy storage capacitors for laser applications was examined in a research paper by Staight of ERA. 6 and 12 μm PVdF film were used giving a capacitance/unit volume of 35 F/m^3 for metallized film 6 μm thick compared with 10 F/m^3 for a similar thickness of polypropylene. The number of discharge operations possible was 10^5 but this was improved to 10^6 using trichlorodiphenyl impregnated film-foil constructions with 6 μm Al foil. However the major disadvantage of PVdF turned out to be the poor stability of capacitance and the change of dissipation factor with temperature which limited the use to temperatures above 0°C. Polypropylene based film-foil structures using phenyl-xylyl-ethane impregnant were found to be usable from −30 to +65°C.

A paper by Kessler of Siemens, West Germany, discussed the use of polyester in stacked film construction and showed that such structures had good pulse mode capability, good self healing properties, and as a result very low failure rates.

Finally, metallized paper capacitors were shown to still be viable devices in a paper presented by Dawson of RIFA, Sweden.

A complete set of papers presented at the seminar is available from ERA, Cleeve Road, Leatherhead, Surrey, UK, at a price of £24 (£15 to ERA members).

D. S. CAMPBELL
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