DIAMOND-LIKE CARBON CAPACITORS FOR HIGH VOLTAGE HIGH ENERGY DENSITY OPERATIONS

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ABSTRACT

Capacitors are a pervasive technology in every military and commercial application. Millions are used in military systems and are considered a critical link and a common area of failure. Capacitors often fail due to increasing environmental temperatures and low reliability, which may be due to low voltage breakdown strengths, high dissipation factors and problems associated with drift of the dielectric constant. Increased performance and smaller size have been the main focus of our research in diamond-like carbon dielectrics for the application of high energy density capacitors. The viability of future military systems will rely on the development of pulse power, high energy density capacitors.

Diamond-like carbon (DLC) possesses the unique properties of high dielectric strength, high resistivity, low loss, high decomposition temperature, chemical inertness, radiation hardness and good thermal conductivity. It has been demonstrated that very thin (0.5 µm) DLC films can be deposited directly onto smooth aluminum surfaces with excellent adhesion and that amorphous DLC films are highly flexible, making them suitable for the production of wound capacitor devices [1]. The DLC film has enabled the demonstration of capacitors produced by rolling DLC coated aluminum into a tubular form. The capacitance of the tubular construction is quite high and the power dissipation factors are low. Moreover, the tubular form lends itself easily to large-scale, low-cost manufacturing. The DLC capacitors are an enabling technology for Directed Energy Weapons (DEW), and High Power Microwave (HPM) demonstration programs.

A prototype manufacturing technology for high energy density and high volumetric efficiency diamond-like carbon (DLC) capacitors has been demonstrated. However, the deposition equipment used for the early work demonstrated that hardware limitations with respect to the deposition rate, maintenance intervals, and web-handling system existed. This work is a continuation of the proof-of-concept work to allow DLC dielectrics to be manufactured using high deposition rate, production scale ion beam equipment processes. This work will investigate the direct deposition of a variety of DLC dielectric materials via ion beam process using a patented Diamonex Closed Drift (CD) Ion Source technology and hardware. Several chemistries have been investigated for the production of DLC films on capacitor grade aluminum foils, and several wound and packaged DLC capacitors were successfully manufactured. These capacitors made with a one micron thick DLC deposition on aluminum foil, exhibit capacitances of roughly 30 nF with a 0.4% dissipation factor at room temperature. The capacitances and dissipation factors of these capacitors as a function of frequency from 100 Hz to 100 KHz were also measured at three different temperatures of -55°C, 25°C and 125°C

A detailed discussion of the manufacturing technology and characteristics of DLC capacitors will be presented.

[1]. S.J. Fries-Carr, R.L.C. Wu, P.B. Kosel, “Capacitor Structures with Dielectric Coated Conductive Substrates”, U.S. Patent No. 5,844,770, December 1, 1998.

[2]. The work was performed under K Systems Corporation Contract No. F33615-03-C-2351 under AF SBIR Phase III Program.