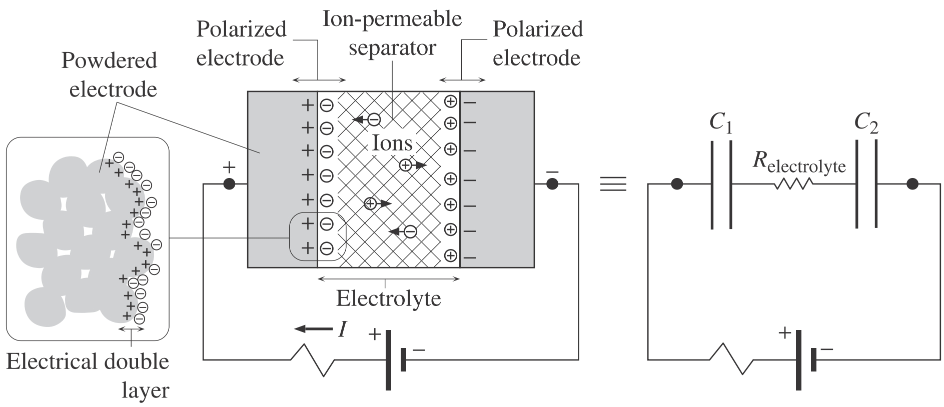

Figure 7.37 A simplified structure of an electrical double-layer supercapacitor. The capacitor is being charged from a battery. Equivalent circuit with C_1 and C_2 representing the capacitances at the electrodes due to polarization at the electrode–electrolyte interface.

Ta_2O_5 is then coated with a thick solid electrolyte, in this case MnO_2. Subsequently, graphite and silver paste layers are applied. Leads are then attached and the whole construction is molded into a resin chip. Solid tantalum capacitors are widely used in numerous electronics applications due to their small size, temperature and time stability, and high reliability.

Supercapacitors or **ultracapacitors** are capacitors with large capacitance values that can be as high as 100 F or more; but with low breakdown voltages, typically a few volts. They store much more energy than conventional electrolytic capacitors per unit volume and essentially function almost like a rechargeable battery for storing and providing energy for various electrical applications. Their principle depends on two factors: increasing the area A and decreasing the thickness d in the capacitance equation $C = \varepsilon_r \varepsilon_o A/d$ to reach higher capacitance values. In one type of supercapacitor technology, called the **electrical double-layer capacitance** (EDLC), the electrodes are powdered carbon (or a similar porous conducting medium), which are separated by an ion-permeable separator soaked in an electrolyte in which there are mobile positive and negative ions. The electrolyte could be an aqueous solution with H^+ and SO_4^- ions, for example. Under an applied voltage, each electrode becomes polarized as in Figure 7.37, somewhat similar to the interfacial polarization at the negative electrode in Figure 7.11b, giving rise to a capacitance at each electrode; shown as C_1 and C_1 in Figure 7.37. There is no actual transfer of charge at the interface but only a separation between charges; that is polarization. One can appreciate that a small separation d between negative and positive charges at the carbon–electrolyte interface can be very small, and less than a nanometer in practice. The powdered carbon increases the effective surface area A. Thus, the capacitance at each electrode becomes very large. These capacitances at the electrodes are in series, connected by the ions in the electrolyte forming a bridge. While supercapacitors serve as convenient rechargeable energy sources, their capacitive performance in terms of frequency response and internal resistance is very limited.