Charge-Dissipative Electrical Cables

Lossy dielectric layers and grounding conductors drain spurious charges to ground.

Goddard Space Flight Center, Greenbelt, Maryland

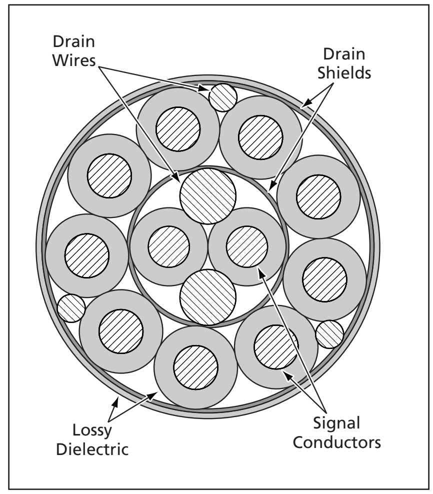
Electrical cables that dissipate spurious static electric charges, in addition to performing their main functions of conducting signals, have been developed. These cables are intended for use in trapped-ion or ionizing-radiation environments, in which electric charges tend to accumulate within, and on the surfaces of, dielectric layers of cables. If the charging rate exceeds the dissipation rate, charges can accumulate in excessive amounts, giving rise to high-current discharges that can damage electronic circuitry and/or systems connected to it.

The basic idea of design and operation of charge-dissipative electrical cables is to drain spurious charges to ground by use of lossy (slightly electrically conductive) dielectric layers, possibly in conjunction with drain wires and/or drain shields (see figure). In typical cases, the drain wires and/or drain shields could be electrically grounded via the connector assemblies at the ends of the cables, in any of the conventional techniques for grounding signal conductors and signal shields. In some cases, signal shields could double as drain shields.

To be suitable for use in a charge-dissipating cable, a dielectric material must be inherently lossy throughout its bulk, and not, say, an insulating polymer with a conductive surface film or containing embedded conductive particles. Conductive surface films can be rendered ineffective by flaking off or cracking, especially when cables are bent. Embedded particles can act as defect sites that initiate arcing within dielectric layers.

The concept of lossiness can be quantified: Dielectric materials can be broadly categorized, as either "excellent" or "lossy" according to their volume electrical resistivity (ρ) values. Excellent insulators may be roughly categorized as having ρ of the order of $10^{16}\Omega\cdot$m, while lossy or dissipative insulators may be categorized as having ρ of the order of $10^{9}\ \Omega\cdot$m.

In designing for a specific application, one must choose the lossy dielectric material and the configuration of grounding conductors to be capable of dissipating a sufficient proportion of static charge within an acceptably short time. For a typical cable that handles signals of sufficiently low frequencies (having wavelengths much greater than the length of the cable), the effective charge-dissipating admittance or conductance must be much less than the nominal signal admittance or signal conductance of the circuits connected with the cable, so as not to adversely affect the transmission of signals. For a typical cable that handles signals of sufficiently high frequencies (having wavelengths comparable to or less than the length of the cable), the effective charge-dissipating admittance or conductance must be taken into account as part of the overall signal-propagation cable impedance, and the signal attenuation caused by loss in the dielectric must be acceptably low. These requirements could be difficult to satisfy if a cable is too long and, hence, imposes either a limit on the allowable length of the cable or else a requirement to pay closer attention to interactions between the charge-dissipation and signal-propagation aspects of the cable design.



This **Cross Section** illustrates one of many possible charge-dissipating designs for a cable containing 11 signal conductors.

This work was done by John R. Kolasinski and Edward J. Wollack of **Goddard Space Flight Center**. *Further information is contained in a TSP (see page 1).*
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Deep-Sea Video Cameras Without Pressure Housings

Camera units could be made smaller, lighter, and less expensive.

NASA's Jet Propulsion Laboratory, Pasadena, California

Underwater video cameras of a proposed type (and, optionally, their light sources) would not be housed in pressure vessels. Conventional underwater cameras and their light sources are housed in pods that keep the contents dry and maintain interior pressures of about 1 atmosphere (≈0.1 MPa). Pods strong enough to withstand the pressures at great ocean depths are bulky, heavy, and expensive. Elimination of the pods would make it possible to build camera/light-source units that would be significantly smaller, lighter, and less expensive. The depth ratings of the proposed camera/light source units would be essentially unlimited because the strengths of their housings would no longer be an issue.

A camera according to the proposal would contain an active-pixel image sensor and readout circuits, all in the form of a single silicon-based complementary metal oxide/semiconductor (CMOS) integrated-circuit chip. As long as none of the circuitry and none of the electrical leads were exposed to seawater, which is electrically conductive, silicon integrated-circuit chips could withstand the hydrostatic pressure of even the deepest ocean. The pressure would change the semiconductor band gap by only a slight amount — not enough to degrade imaging performance significantly.

Electrical contact with seawater would be prevented by potting the integrated-circuit chip in a transparent plastic case. The electrical leads for supplying power to the chip and extracting the video signal would also be potted, though not necessarily in the same transparent plastic. The hydrostatic pressure would tend to compress the plastic case and the chip equally on all sides; there would be no need for great strength because there would be no need to hold back high pressure on one side against low pressure on the other side. A light source suitable for use with the camera could consist of light-emitting diodes (LEDs). Like integrated-circuit chips, LEDs can withstand very large hydrostatic pressures.

If power-supply regulators or filter capacitors were needed, these could be attached in chip form directly onto the back of, and potted with, the imager chip. Because CMOS imagers dissipate little power, the potting would not result in overheating. To minimize the cost of the camera, a fixed lens could be fabricated as part of the plastic case. For improved optical performance at greater cost, an adjustable glass achromatic lens would be mounted in a reservoir that would be filled with transparent oil and subject to the full hydrostatic pressure, and the reservoir would be mounted on the case to position the lens in front of the image sensor. The lens would by adjusted for focus by use of a motor inside the reservoir (oil-filled motors already exist).

This work was done by Thomas Cunningham of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30774

RFID and Memory Devices Fabricated Integrally on Substrates

These molecularly bonded devices would be much thinner than microchips.

Marshall Space Flight Center, Alabama

Electronic identification devices containing radio-frequency identification (RFID) circuits and antennas would be fabricated integrally with the objects to be identified, according to a proposal. That is to say, the objects to be identified would serve as substrates for the deposition and patterning of the materials of the devices used to identify them, and each identification device would be bonded to the identified object at the molecular level. Vacuum arc vapor deposition (VAVD) is the NASA–derived process for depositing layers of material on the substrate.

This proposal stands in contrast to the current practice of fabricating RFID and/or memory devices as wafer-based, self-contained integrated-circuit chips that are subsequently embedded in or attached to plastic cards to make “smart” account-information cards and identification badges. If one relies on such a chip to store data on the history of an object to be tracked and the chip falls off or out of the object, then one loses both the historical data and the means to track the object and verify its identity electronically. Also, in contrast is the manufacturing philosophy in use today to make many memory devices. Today’s methods involve many subtractive processes such as etching. This proposal only uses additive methods, building RFID and memory devices from the substrate up in thin layers. VAVD is capable of spraying silicon, copper, and other materials commonly used in electronic devices. The VAVD process sprays most metals and some ceramics. The material being sprayed has a very strong bond with the substrate, whether that substrate is metal, ceramic, or even wood, rock, glass, PVC, or paper.

An object to be tagged with an identification device according to the proposal must be compatible with a vacuum deposition process. Temperature is seldom an issue as the substrate rarely reaches 150° F (66° C) during the deposition process. A portion of the surface of the object would be designated as a substrate for the deposition of the device. By use of a vacuum arc vapor deposition apparatus, a thin electrically insulating film would first be deposited on the substrate. Subsequent layers of materials would then be deposited and patterned by use of known integrated-circuit fabrication techniques. The total thickness of the deposited layers could be much less than the 100-µm thickness of the thinnest state-of-the-art self-contained microchips. Such a thin deposit could be readily concealed by simply painting over it. Both large vacuum chambers for production runs and portable hand-held devices for *in situ* applications are available.

This work was done by Harry F. Schramm of **Marshall Space Flight Center**.

This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at (256) 544-5226 or sammy.a.nabors@nasa.gov. Refer to MFS-31549.