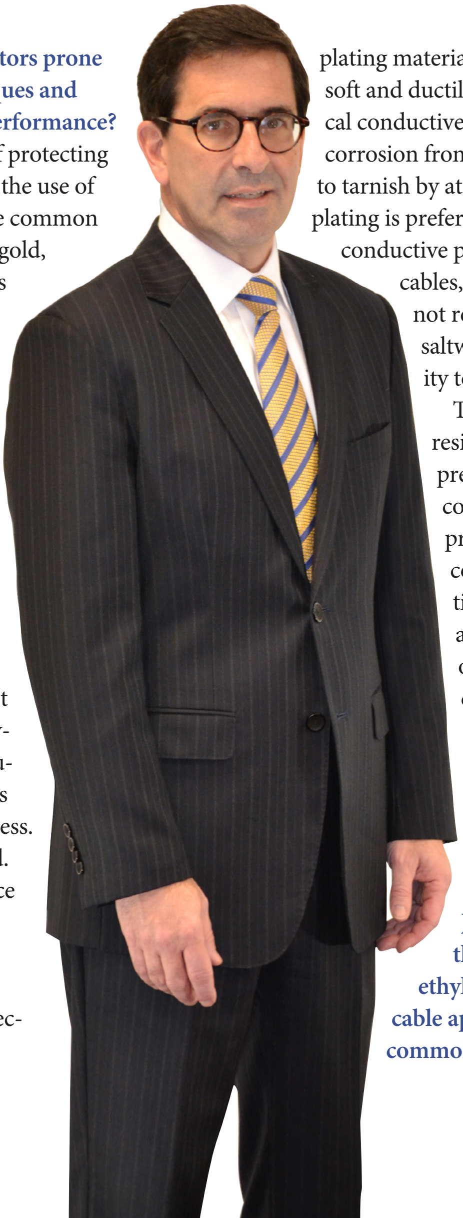
Inside TRACK with Chris Kneizys,

President/CEO of Micro-Coax

Interview by JEAN-JACQUES DeLISLE



JJD: With copper and aluminum conductors prone to oxidation and corrosion, what techniques and materials can be used to enhance their performance?

CK: Probably the most common means of protecting these materials from oxidation is through the use of barrier coatings. Such coatings include the common electroplated surface layers. For example, gold, silver, and tin are often used to protect less noble metals from corrosion; preserve or enhance solderability; and provide a pleasing appearance. The coatings must be thick enough to protect the conductor during its service lifetime. Often, an intermediate layer like nickel is used to reduce porosity and inhibit the migration of the basis metal to the surface.

Other barrier methods of protection include jacket extrusions or dips, which apply a polymer film to the material and thus keep out oxygen and moisture. Coatings like benzotriazole—a transparent organic coating—temporarily exclude oxygen from the surface of the metal. Unfortunately, benzotriazole eventually evaporates and thus has a limited period of effectiveness.

Aluminum conductors can be anodized. This process actually accelerates the surface oxide growth. The resulting thick, well-formed oxide film is stable and passive.

Copper and aluminum conductors are often plated for additional corrosion protection and solderability. The most common plating materials are tin and silver, which are very soft and ductile. While silver has superior electrical conductive properties and is very resistant to corrosion from atmospheric oxygen, it is vulnerable to tarnish by atmospheric sulfides and nitrates. Silver plating is preferred anytime the material is part of the conductive path inside the cable. For semi-rigid cables, silver-plating the outer conductor is not recommended for high-humidity or saltwater environments due to susceptibility to galvanic corrosion or red plague.

Tin plating is economical, corrosion-resistant, and highly solderable. It is preferred for semi-rigid-cable outer conductors. However, tin plating can be prone to tin whiskers. These electrically conductive, crystalline structures sometimes grow from surfaces that use tin as a final finish. They can grow to lengths of several millimeters. Tin whiskers could cause short circuits by bridging closely spaced circuit elements, which are maintained at different electrical potentials. Adding a small amount of lead to the plating, referred to as electro-deposited solder (EDS), can eliminate tin-whisker risks.

JJD: What techniques help enhance the performance of polytetrafluoroethylene (PTFE) for different coaxial-cable applications? Are any other materials commonly used as a coaxial dielectric?

CK: Most semi-rigid cables utilize full-density PTFE in the solid form. However, larger semi-rigid cables are also available in a spline configuration. Spline dielectrics have a thin layer of material around the center conductor with three to five spokes projecting radially outward. The majority of a spline insulator is air, which yields an effective relative dielectric constant as low as 1.3. It should be noted that spline dielectrics, in general, are considerably more expensive than their solid PTFE counterparts.

Low-density PTFE and ultra-low-density PTFE utilize the same base material as the full-density version, but they are processed differently. The lower density reduces both the dielectric constant and dissipation factor, which leads to an overall lowering of the cable attenuation. The lower-density PTFEs are also more thermally stable when compared to solid PTFE. However, there is a tradeoff: Any time there's a drop in dielectric density, it reduces the mechanical integrity. As a result, cables employing a lower-density or spline dielectric will have larger minimum bend radii when compared to the solid full-density versions.

Sometimes, fluorinated-ethylene-propylene (FEP) and perfluroalkoxy (PFA) dielectrics are used when the need arises for very thin walls. Examples include those on low-impedance semi-rigid cables. Both FEP and PFA have properties that are similar to PTFE.

JJD: How do materials and techniques for strengthening a flexible coaxial cable impact the cable's performance?

CK: Techniques for strengthening can be applied to the cable design itself, or to complementary protection (armoring) layers. In the case of armoring, the goal is usually for the armoring layers to be invisible to the signals that are propagating in the coaxial cable. In some cases, the armor can restrict the cable from mechanical distortions, thereby improving electrical performance in the application.

Armoring typically involves a high-strength stainless-steel hose, similar to the old payphone cords, or a jacketed stainless-steel spiral. Lately, internal armoring has become more popular. This type of armoring is similar to the other armoring, except the strength member is integrated into the cable. It has the advantage of being less bulky.

JJD: Are certain coaxial materials better or worse suited for automated manufacturing? What techniques enable the efficient automated manufacturing of coaxial cables?

CK: Material and finish selection can be critical to the assembly or manufacturing methods applied. In most cases, we're able to enhance manufacturability without trading off electrical performance. For example, we can use a silver-plated copper conductor for the primary cable shield, but select a different alloy or composite for the secondary shield. The secondary shield can then be chosen to optimize the manufacturing method. For example, an alloy could be selected to manage solder wicking or enable use of compression or crimp fittings.

Equally important is the design of the connectors. Research suggests that the design phase of an assembly assumes as much as 80% of the product cost. Thus, it should not be a surprise that a coaxial connector originally designed for manual solder attachment is not optimum for automation. For high-volume applications, we always prepare ourselves for connector design enhancements.

Mostly because of cost considerations, semi-rigid cable has found the widest adoption for high-volume applications, like consumer electronics, where automation is justified. Semi-rigid cable is selected for a number of reasons, the biggest being that it is straight as opposed to coiled. This allows for precision cable location, resulting in maximum tolerance control. The finished assemblies can be put on tape and reel and used with pick-and-place robots. While semi-rigid cable is the most commonly used cable for automation, high-quality cables also lend themselves to automation. They offer very tight mechanical tolerance control on the various material diameters required to operate at microwave frequencies.

JJD: What are the benefits and drawbacks of metal-clad fibers?

CK: Metal-clad fibers (MCF) carry three key benefits: light weight, flexibility, and strength. MCF, when compared to copper, can reduce the weight of a braid by as much as 80%. MCF has a textile-like feel with no bend memory. In addition, its flex life is orders-of-magnitude longer than equivalent copper wire. Besides being a good electrical conductor, MCF is metal-plated with KEVLAR—a material stronger than steel that's used in bullet-resistant vests. So it can also be used as the primary strength member in any cable or harness. MCF is ten times stronger than copper. Compared to equivalent AWG copper wire, though, MCF will have a higher dc resistance. Known as ARACON, that braid is substantially stronger and more durable than the silver-plated copper braid wire that it replaces. Another "side benefit" of the lightweight ARACON braid, when compared to a metal braid, is that less force is delivered to the inner and outer cable component layers during integration, flexure, and handling. The reduction in force increases performance life for the cable.

JJD: How do metal-clad fibers operate for applications such as EMI shielding? What other applications can the material serve?

CK: The primary applications for MCF have been the outer shield of a coaxial cable and a braided or woven EMI shield for wires or harnesses. The large number of very fine fibers, together with the tendency of yarn bundles to flatten and spread, makes it easy to obtain high coverage levels with reduced windowing. Ease of pushback on the braid is maintained even at high coverage. Braids built with MCF can be soldered or crimped, and are a direct substitute for copper braids built to A-A-59569. Due to the textile-like properties and strength of MCF, we also find applications in wearable electronics and athletic gear. mw