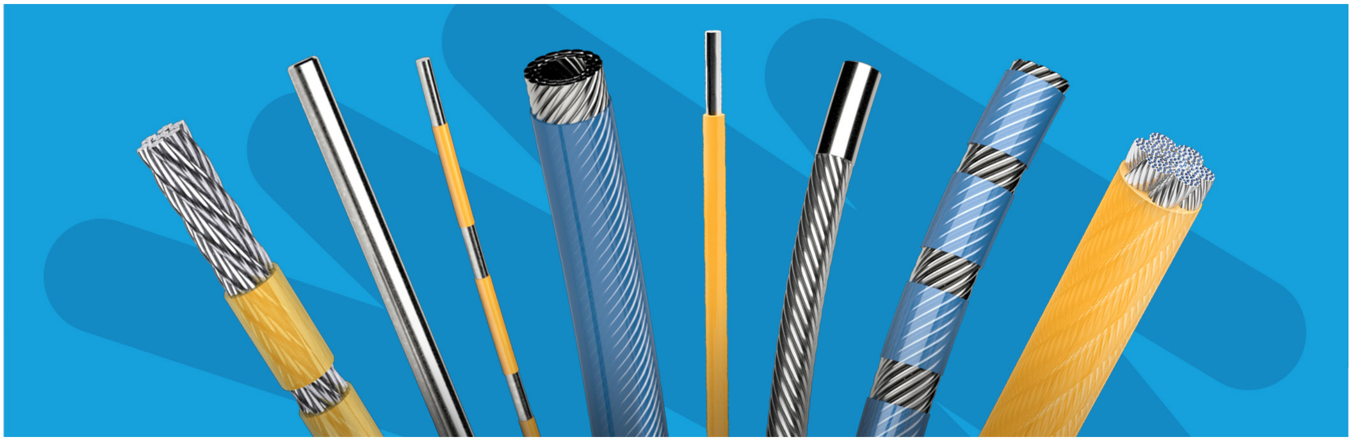
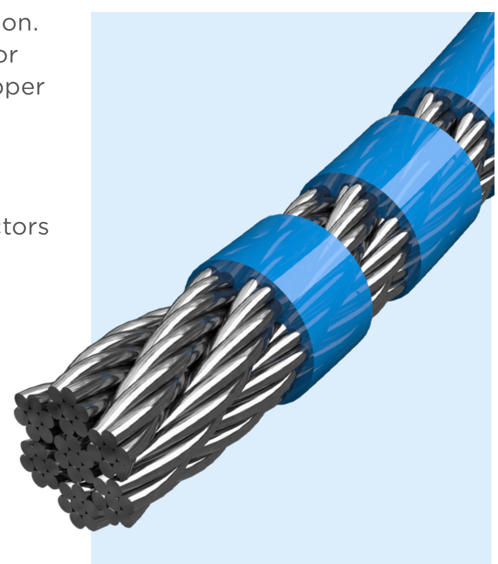


Advanced Coatings and Laser Ablation for High-performance Materials in Medical Devices

A precision wire rarely serves one single function across its entire length in a medical device. In a catheter lead or neurostimulation conductor, one zone must carry a signal without loss, the next must navigate freely through a lumen, and a third must make direct metal contact with tissue — all within a few millimeters of each other. The coating system, not the wire itself, is what reconciles those competing demands.

Coatings for medical wire fall into two categories: dielectric coatings, which electrically insulate; and lubricious coatings, which reduce friction. The categories overlap, and some fluoropolymers do both jobs reasonably well. In practice, the dominant property requirement at each location tends to drive both coating selection and the wall thickness the construction can accommodate.

Dielectric coatings



Extrudable fluoropolymers are the workhorses of medical-wire insulation. The most widely used is ethylene tetrafluoroethylene (ETFE), valued for mechanical strength, abrasion resistance, and impact resistance. Its upper service temperature is around 150 °C [302 °F].

Perfluoroalkoxy (PFA) trades some of that mechanical robustness for higher temperature performance and better lubricity, with a service temperature near 260 °C [500 °F]. PFA appears frequently on conductors that slide through a lumen during assembly or use, where its lower surface friction contributes to pushability.

Fluorinated ethylene propylene (FEP) sits between ETFE and PFA on most properties and is often selected for applications requiring greater flexibility than ETFE while maintaining the chemical resistance and dielectric performance expected of fluoropolymers.

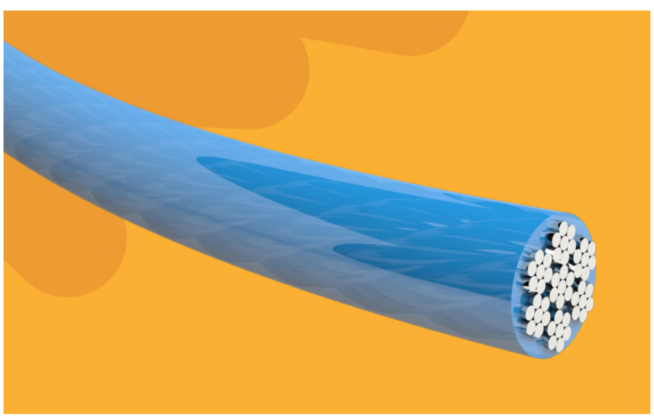
Extrudable polytetrafluoroethylene (PTFE), sold as Moldflon™, offers PTFE-class lubricity and significantly lower friction than ETFE while still permitting continuous extrusion over a strand or cable. Its service temperature is comparable to PFA, and its dielectric strength sits in the same range as the other fluoropolymers, roughly 1,500 to 1,800 volts per mil [1,500,000 to 1,800,000 volts per in].

All four of these materials can be pigmented for color-coded assembly, which is useful for error-proofing in multi-conductor devices.

Extrudable coatings also accept fluted die geometries. Small ribs or lobes can be molded into the inside or outside of the coating, creating air pockets that further reduce friction between the wire and whatever lumen or device it slides against.

Polyimide enamel sits in a different category. Where fluoropolymers behave as a jacket over the conductor, polyimide adheres directly to the wire surface. The dielectric improvement is significant. A polyimide coating delivers roughly three times the volts-per-mil performance of a fluoropolymer, which means a designer can reach 1,800 to 2,000 volts at about a third of the wall thickness.

That three-to-one thickness advantage matters when a catheter or lead must fit a tight anatomical space. Reducing the conductor's outside diameter, even by a few thousandths, can be the difference between a device that fits a peripheral vessel or pediatric anatomy and one that does not. The trade-off is that an adherent enamel works best on solid wire. For stranded or cabled constructions requiring flexibility, an extruded jacket is the more common approach. Enamels are also tough and abrasion-resistant, which makes them suitable for coiled constructions where the wire experiences rubbing against itself or adjacent components.



Lubricious coatings

When the primary job of the coating is friction reduction rather than insulation, PTFE is the go-to material. Best known as Teflon®, PTFE is the conventional choice on guidewires and catheter shafts where the device needs to traverse tortuous vasculature with minimal resistance.

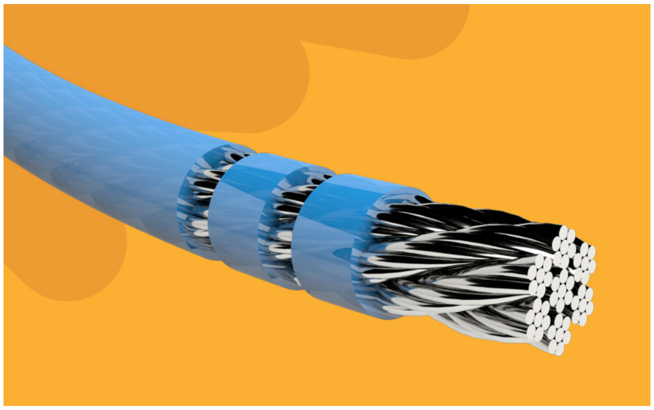
PTFE coatings come in several process variants. Extrudable PTFE behaves like a continuous jacket. Paste-extruded, dip-coated, and sprayed PTFE coatings, applied either continuously or in discrete sections, give designers different options for thickness control and substrate adhesion.

Nylons add a different property. Grilamid® is mechanically tough and pigmentable, but offers neither the dielectric performance of polyimide nor the lubricity of PTFE. Its role is wear protection — an extra abrasion layer for a strand or cable that will ride against a pulley, guide, or adjacent surface during operation. Pebax® is valued for flexibility and the ability to bond to other polymer layers. That bondability is why it appears so often in multilayer catheter constructions, where a hydrophilic coating may be applied over Pebax® to deliver wet lubricity in vivo.

The practical pattern is that lubricious and dielectric coatings are often layered. A catheter shaft may use a Pebax® body for flexibility, a hydrophilic outer layer for in vivo lubricity, and an inner liner of PTFE to reduce friction against the device that passes through it. A lead conductor may use a twisted pair of conductors where each is coated with PFA, which reduces surface friction and prevents chafing between the conductors, and the pair is then jacketed with ETFE to hold them together and provide column strength where pushability matters.

Laser ablation

In most cases, coating a conductor is only half the challenge. Wherever the conductor has to terminate at a weld, crimp, electrode contact, or sensing window, the coating has to come off. Mechanical stripping with blades works at scale but introduces two recurring problems for medical wire: tolerance variation and the risk of nicking the conductor. On small-diameter wire, nicks from mechanical stripping can compromise mechanical integrity and serve as fatigue initiation sites.



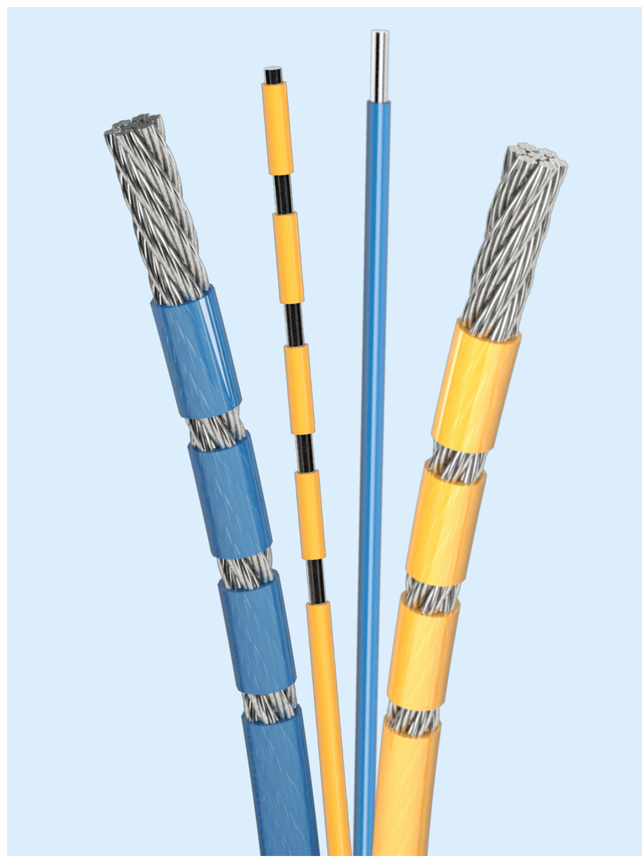
Laser ablation removes coating without touching the wire. The laser energy is tuned to the coating material's absorption while the underlying metal reflects enough of it that the conductor is largely undamaged. Beyond that baseline, the practical advantage is what laser ablation enables in device design. Cleanly defined ablation windows, which are short sections of exposed conductor mid-length rather than at the end, let a designer place sensing or stimulation electrodes anywhere along the conductor. Customizable zones along a single wire support multi-electrode geometries without separate terminations. Lasers tuned specifically for ETFE handle the most common case; PFA, polyimide, and other coatings can be ablated through partner conversion processes.

Coating combinations in practice

A conductor for a neurostimulation lead may carry ETFE primary insulation for dielectric strength and abrasion resistance, with selectively ablated windows along its length for electrode contacts. A guidewire may use a stainless or Nitinol core with PTFE for lubricity over most of its length and a polyimide insulation segment where it carries signal. A diagnostic catheter conductor needing to fit a small anatomy may use polyimide enamel for the dielectric, gaining the thickness reduction the application requires.

In each case, the question is not which single coating is best overall, but which coating belongs at each point along the wire and where it must be removed to allow termination or sensing. Together, the polymer selection and ablation strategy define what a single conductor can do. The engineering value comes from matching those choices to the device's anatomy and function.

Fort Wayne Metals works with device designers to align coating strategy and laser ablation requirements with the functional demands of each section of wire. If you are weighing insulation, lubricity, or selective exposure needs in a new or existing design, our engineering team can help you evaluate the trade-offs and define the right approach for your application.



To learn more, visit fwmetals.com

Coating properties

You can use the following charts to determine which dielectric or lubricious coating offers the properties you need for your application. If you'd like to speak to an engineer about coating possibilities, please contact us.

Dielectric coatings

Coating type	Density	Tensile strength		Coefficient of friction	Dielectric strength		CTE at 20 °C	Water absorption	Service temp. in air (max)
%	g/cm³	MPa	ksi		kV/mm	V/mil	µm/m/°C	%	°C [°F]
ETFE	1.70	41	6000	0.3	64	1600	130	0.006	150 [302]
PFA	2.15	28	4000	0.2	62	1575	140	0.05	260 [500]
Moldflon PTFE	2.17	36	5260	0.1	60	1525	130	0.01	260 [500]
PI	1.42	138	20000	0.35	192	4800	20	1.8	240 [464]
FEP	2.15	25	3600	0.24	62	1575	140	0.005	200 [392]

Lubricious coatings

	DuraSkin™	LubriSkin™
Coating thickness	Standard: 4 – 10 µm [0.00016 in – 0.00039 in]	Standard: 4 – 10 µm [0.00016 in – 0.00039 in]
Uncoated diameter	0.15 mm – 0.965 mm [0.0059 in – 0.038 in]	0.038 mm – 0.70 mm [0.0015 in – 0.0276 in]
Colors	Green, gray, blue*, black, white, clear	Green, other colors on request
Primary uses	Corewires, (PTCA) extrusion mandrel wire	Coiling wire, bonding mandrels, release mandrels
Supplied	Straightened and cut lengths, spooled	Straightened and cut lengths, spooled
Gamma stable	Yes	No
ETO sterilization	Yes	Yes
Biocompatibility	For invasive techniques, excluding permanent human implants	For invasive techniques, excluding permanent human implants
Heat stability	Up to 195 °C [390 °F]	Up to 205 °C [400 °F]
Chemical resistance	Sensitive to some solvents like NMP, acetone, MEK, etc.	Good to excellent

**Blue DuraSkin™ coating uncoated diameter range: 0.20 mm to 0.965 mm [0.0079 in to 0.038 in].*