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TECHNICALTIDBITS

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Here comes your 19th dielectric breakdown!
– Under high enough electrical stress, even electrical insulators have their breaking points.

- **Dielectric Breakdown**
- **Breakdown voltage**
- **Dielectric Strength**
- **Arcing**
- **Corona**
- **Corona Discharge**

The next issue of Technical Tidbits will discuss ferroelectric and piezoelectric materials.

DIELECTRIC BREAKDOWN & DIELECTRIC STRENGTH

Under normal circumstances, dielectric materials do not allow electrical current to pass through them, even when they have a potential (voltage) across them. This is the definition of an electrical insulator. However, all materials will eventually conduct current, if the applied potential is high enough. The process by which this occurs is called **dielectric breakdown.**

The value of electrical potential at which this occurs is called the **breakdown voltage** (measured in volts). The **dielectric strength** is the potential gradient at which this occurs (expressed in volts per meter, kV/mm, etc.). The difference is important, since the breakdown voltage will be larger for thicker materials and smaller for thinner materials, but the dielectric strength will (theoretically) remain unchanged. Dielectric strength is thus more like a material property, and breakdown voltage is more like a system property.

Back in 2012, Technical Tidbits Issue Number 40 discussed **arcing** between electrical contacts. To summarize, when the electrical potential between oppositely charged contacts reaches the breakdown voltage for the distance between the contacts, electrons will have sufficient energy to escape the cathode and travel to the anode. Along the way, the electrons collide with and ionize gas molecules between the charged contacts, producing more free electrons attracted to the anode. Meanwhile, the positive ions are attracted to the cathode and travel towards it. As the ions and electrons collide with the contacts, the contacts are heated and emit more ions and electrons in a positive feedback process. Electrons will flow through this arc until the voltage and or current falls below the critical threshold, and the arc extinguishes.

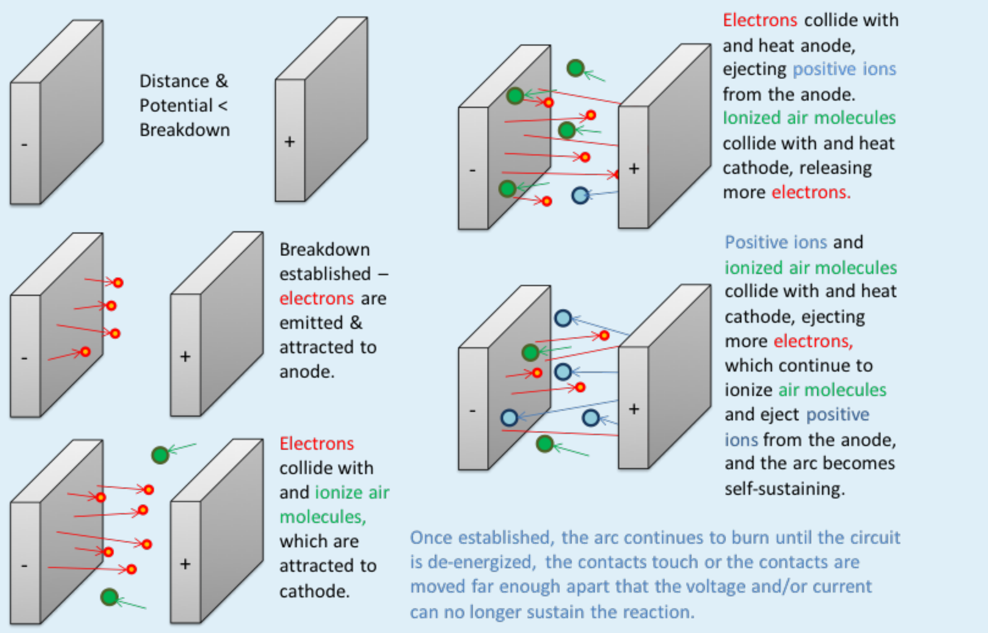

Figure 1 –Arc Initiation in Air.
This provides a detailed description of how electrical arcs form when the two halves of the connector interface are brought together under sufficient voltage to initiate electrical breakdown of the gap and the subsequent arc.

DIELECTRIC BREAKDOWN AND DIELECTRIC STRENGTH (CONTINUED)

Even in a theoretically perfect vacuum, at high enough potential, electrons in the cathode will have enough energy to escape from the surface of the cathode and cross over to the anode.

A similar process occurs within dielectric materials. Breakdown usually occurs internally at voids, holes, or other defects within the material. These are usually filled with gas. When the whole material is under a potential gradient, the dielectric on either side of the gas pocket will have different charges. At a sufficiently high potential gradient, internal arcs will form within the dielectric material across these voids. The dielectric insulator has now become a conductor.

There are several consequences of this process. One is that the manufacturing quality of the material (such as number and size of voids, internal contamination, and similar defects) will affect its actual dielectric strength. Another is that the actual dielectric strength of a material will always be less than the maximum theoretical value. The dielectric strength will vary from batch to batch.

The other consequence is that it takes time for the breakdown process to occur. If the applied field is removed before the breakdown has time to begin, there will be no failure. So, it would take a larger gradient to initiate breakdown for short term exposures than it would for steady state exposure. So, even the frequency of the applied electric field affects the dielectric strength.

Corona is another potential failure mechanism of dielectric materials. Sharp points or edges concentrate the electric field in that location. This intensified field has the potential (in more ways than one) to ionize the surrounding air molecules. This is the mechanism responsible for St. Elmo's fire (the physical phenomenon, not the 1980's movie, and my apologies if you now have the theme song stuck in your head). St. Elmo's fire is the glow that occurs at the tops of tall, pointed objects like ships' masts when thunderstorms approach. Lightning rods take advantage of this affect, using charge concentration at the tip of the rod to provide an easy, defined path to ground that bypasses critical structures.

Air molecules ionized by corona will then be able to conduct charge, in a process called **corona discharge.** Note that corona discharge is another means by which breakdown can occur in the voids within the dielectric. Corona discharge is affected by applied voltage, shape of the dielectric, atmospheric composition and humidity.

When testing the dielectric strength of a material, it is important to note how the field was applied, as the strength can vary with the size and shape of the electrodes, as well as the size and shape of the dielectric. Even the composition of the surrounding air and its relative humidity will have an effect.

Written by Mike Gedeon of Materion Performance Alloys Marketing Department. Mr. Gedeon's primary focus is on electronic strip for the automotive, telecom, and computer markets with emphasis on application development.

References:

Nicholas Braithwaite and Graham Weaver
Electronic Materials 2nd Edition
© 1998 The Open University

Jearl Walker
Fundamentals of Physics 8th Edition
© 2008 John Wiley & Sons, Inc.

Ginsberg, Gerald R.
Connectors and Interconnections Handbook Volume 4 Connector Materials
© 1983 The Electronic Connector Study Group, Inc.

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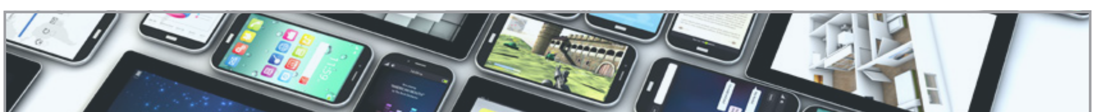

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Materion Performance Alloys
6070 Parkland Blvd.
Mayfield Heights, OH 44124

MATERION

Sales
+1.216.383.6800
800.321.2076
BrushAlloys@Materion.com

Technical Service
+1.216.692.3108
800.375.4205
BrushAlloys-Info@Materion.com