What do you offer in mica?

Mica ---- Nature's Versatile Insulator.

Continuing the technology that started our holding company, Perfection Mica Company, more than 65 years ago, we offer the finest quality mica for use in the electrical industry.

Mica has a high dielectric strength and excellent chemical stability, making it a favored material for manufacturing capacitors for radio frequency applications. It has also been used as an insulator in high voltage electrical equipment. It is also birefringent and is commonly used to make quarter and half wave plates.

Of nine different types of mica, two are important in the electrical/electronic industry in such applications as electron tubes, capacitors, generators, and insulating spacers for semiconductors. These are muscovite (potassium mica) and phlogopite (magnesium mica).

Mica is very stable at high temperatures, and possesses some attractive electrical properties. It is flexible, chemically inert, and has good mechanical strength perpendicular to the lamina.

Phlogopite mica has inferior electrical characteristics compared to muscovite, but offers other properties that are superior. Phlogopite is a bit softer and weaker then muscovite, however it has the advantage of being able to withstand higher temperature-up to 850°C and more. Muscovite handles up to 600°C before it suffers physical changes.

We provide mica parts fabricated to your specifications and drawings. For a more in depth discussion of the electrical and physical characteristics of Mica please refer to our literature section for Mica Manual K-13A which follows.

MICA—
Nature's Versatile Insulator

MICA MANUAL K-13A

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MICA

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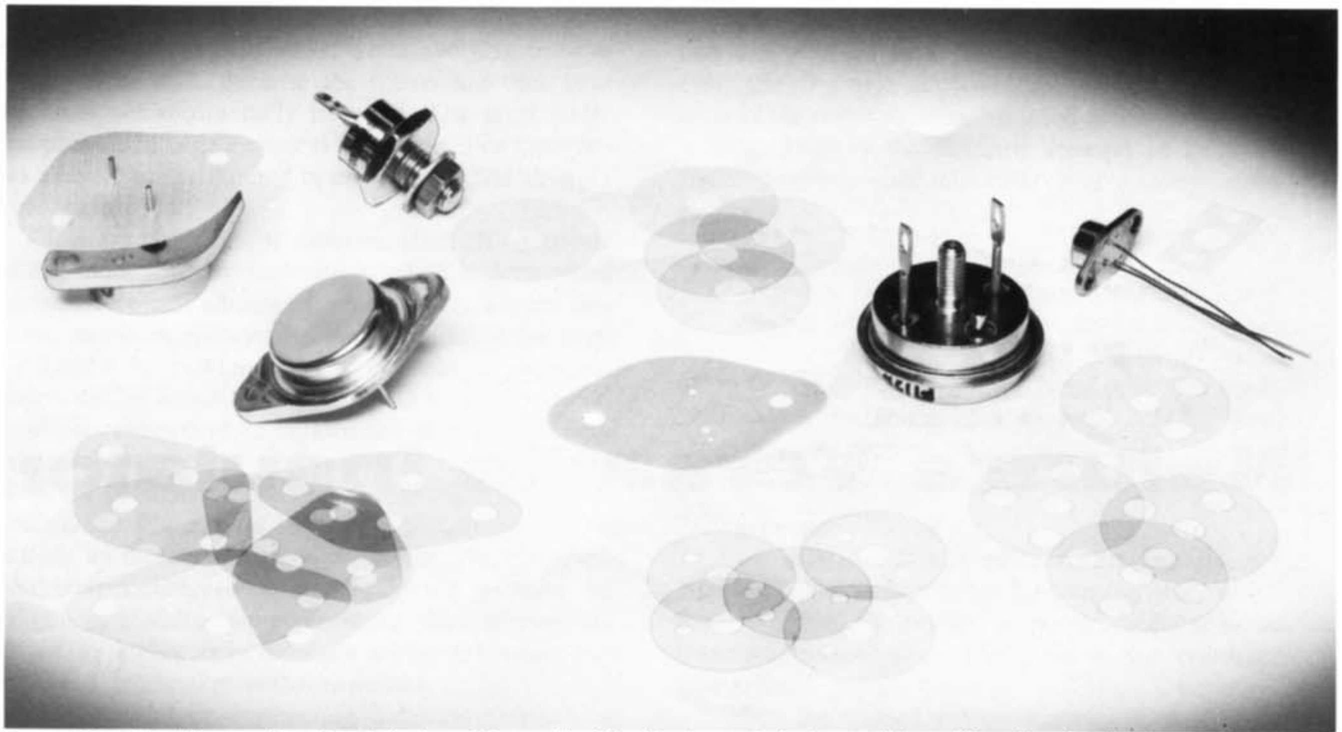

Fig. 1—Mica wafers insulate transistors electrically from their heat sinks, while allowing heat transfer.

MICA—
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A survey of the electrical and physical characteristics of muscovite and phlogopite

Fig. 2—Effect of temperature on clear muscovite intrinsic dielectric strength.

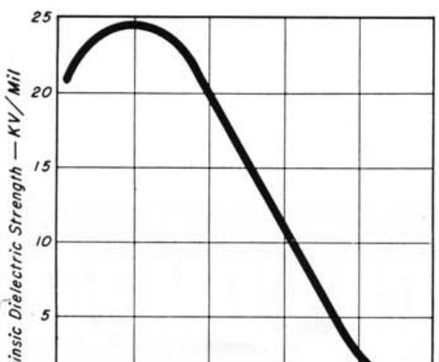


Fig. 3—Apparent dielectric strength vs. thickness of clear muscovite at 60 Hz.

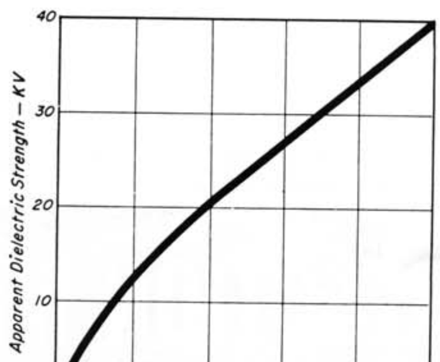
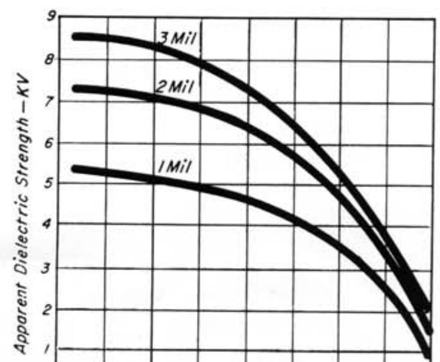


Fig. 4—Apparent strength-temperature characteristic of mica tested in air at 60 Hz.



Mica—which comes from the Latin "micare," meaning to sparkle—is a mineral silicate found throughout the world. Of nine different types of mica, two are important in the electrical/electronic industry in such applications as electron tubes, capacitors, generators, and more recently, as insulating spacers for semiconductors. These are muscovite [$KH_2Al_3(SiO_4)_3$], called potassium mica, and phlogopite [$KH_2Mg_3Al(SiO_4)_3$], known as magnesium mica. The composition and physical structure varies according to individual deposits in different geographical locations.

India is the leading source, though Brazil and other countries are also important producers of the valuable block, film and splittings; that is, high quality sheets. Scrap mica, which may be bonded with a binder, is produced in the United States, South Africa, Argentina and elsewhere. Synthetic mica is also manufactured, and its properties are comparable with natural mica. Natural mica is often split into layers as thin as 0.001″, and numerous layers may be built up. The high labor content of producing thin splittings is the reason this work is usually done in the foreign source country.

Mica quality is graded according to standards established by the American Society for Testing Materials and the National Electrical Manufacturers Association. The main grading criterion relates to staining and foreign body inclusions. A clear specimen would be of top quality, moderately stained would be of medium quality, and densely stained and spotted would be of low quality. Electrical characteristics are related to, but not necessarily defined by, the visual appearance of a mica specimen. Large area sheets of excellent grade are more rare and costly then small area pieces.

Mica has, on rare occasion, been split in layers as thin as 0.15 mil, though 1 to 25 mils is more typical. Production handling of films under 0.75 mil is usually not practical. If splittings are to be used for punching blanks, thickness no greater than 5 mils is used since unpredictable delaminations occur in heavier mica.

Mica is very stable at high temperatures, and possesses some attractive electrical properties. It is flexible, chemically inert, and has good mechanical strength perpendicular to the lamina.

Muscovite mica shows no physical change up to 600°C. It has a density of about 3 grams/cc, a hardness of 3.5 to 4.2 Moh, and comes in a wide range of colors which vary according to source location and thickness. India ruby, a pale brownish red in 0.020″ sheets, is popular for electrical applications because of its high resistivity, between 10^{15} and 10^{16} ohm-cm, high dielectric constant of 6 to 7, low power factor of 1×10^{-4} to 3×10^{-4}, and a 2 kv/mil dielectric strength.

Phlogopite mica has inferior electrical characteristics compared to muscovite, though it offers other properties which are superior. For example, phlogopite resistivity is between 10^{12} and10^{14} ohm-cm, dielectric constant is 5 to 6, power factor on the order of 50×10^{-4} (low Q), and dielectric strength is about 1.5 kv/mil. Phlogopite is a bit softer and weaker than muscovite. However, phlogopite has the advantage of being able to withstand higher temperatures—up to 850°C and more.

In discussing all of these mica characteristics it should be recognized that the figures are representative of the better quality grades. According to a study of the literature by engineers of the Perfection Mica Company, in such important characteristics as Q at 1 MHz, the Q might be 2500 for a high grade, 1500 for a medium grade, and 200 for a low grade. Because mica is a natural mineral, there will be a tolerance range of performance properties even within a given grade.

Dielectric Strength

Fig. 1 shows a group of mica wafers designed by

Fig. 5—Power factor of clear ruby muscovite as a function of temperature at 60 Hz.

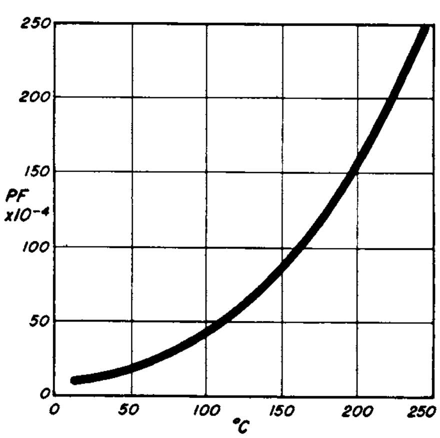


Fig. 6—Power factor-temperature characteristics of mica at high frequencies.

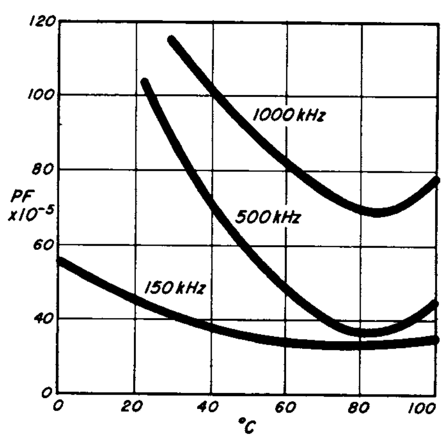
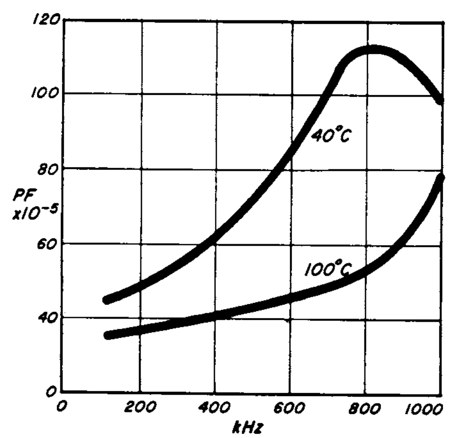


Fig. 7—Power factor-frequency characteristics of mica for two temperature ranges.



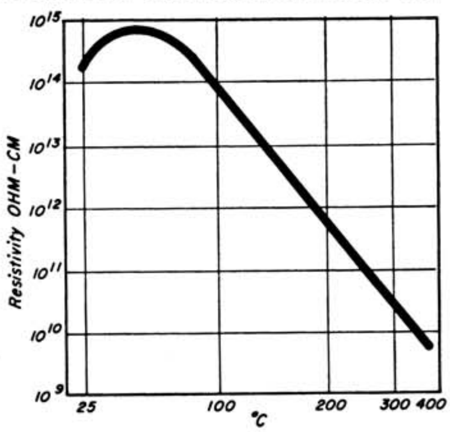
Perfection Mica to provide transistors with electrical isolation from their heat sinks, while allowing transfer of heat to the sink. Because the wafers are thin, heat transfer is not substantially impeded. The mica wafer must provide reliable electrical insulation. For this purpose a better understanding of mica's dielectric strength would be in order.

There are two types of dielectric strength—intrinsic and apparent. Intrinsic dielectric strength is determined in a manner which eliminates concern over corona discharge, and is independent of the thickness of the sample. Tested in this manner, the intrinsic dielectric strength will be about 25 kv/mil, or close to 10^7 v/cm. The effect of temperature on intrinsic dielectric strength is shown by the curve of Fig. 2. Between 100° and 200°C the strength decline with increasing temperature is essentially linear, and relates to the absorption of electrons by the crystal structure. Below 0°C, the transition temperature, there is actually an increase of strength with rising temperature, a phenomenon attributed to higher crystal lattice vibrations being accompanied by smaller electron motion.

The apparent or engineering dielectric strength is much lower than the intrinsic value because it must take into account minute imperfections, and further, because it is limited by the formation of a corona discharge preceding actual breakdown. As a general measure, 2 kv/mil is a representative apparent dielectric strength, though 1 kv/mil may be a more realistic, conservative figure to use in practical designs. However, for high quality grades, 1 mil (0.001″) thick or less, it may run closer to 5 kv/mil a-c rms. The equivalent d-c breakdown would be 8.5 kv/mil, which is a d-c/a-c ratio of 1.7, depending upon thickness, temperature, voltage and frequency.

Mica exhibits high voltage gradients in very thin layers, decreasing as the layer thickness increases. See Fig. 3. Here, a 2 mil clear ruby muscovite at 60 cps has over 5 kv of strength, while a 30 mil thick section has only 40 kv.

Fig. 8—Resistivity-temperature characteristic of muscovite measured at d-c.



When mica is immersed in oil, corona and ionization are initiated at a higher voltage than air. However, the discharge is more severe in oil, and consequently the dielectric strength in oil is less than air.

Fig. 4 shows the dielectric strength in kv for different thicknesses of muscovite over a range of temperatures.

Dielectric Constant

At 25°C at 800 Hz (cps), muscovite shows a dielectric constant of 6.0 to 7.1 for clear mica, and about 6.5 to 7.0 for stained mica. One highly useful property of mica, particularly for capacitors, is the very positive temperature coefficient of 1 to 3 x 10^{-5}/°C. Today, silver mica capacitors with positive TC of not more than 10 ppm/°C may be produced.

Power Factor

Low dielectric loss is another attractive feature of muscovite. Power factors are low, on the order of 10^{-4}, though higher PF results at power frequencies with increasing temperatures. Fig. 5 shows this relationship at 60 Hz.

When the applied voltage across a mica layer is at a high frequency, a curious reversal takes place in the power factor-temperature relationship. The PF *decreases* with increasing temperature up to a critical temperature of 80° to 90°C. Fig. 6 shows this, and also indicates the lower PF of the lower r-f frequencies. The transition temperature is a bit higher at higher frequencies, and beyond this temperature PF increases with frequency.

The power factor increases as the frequency approaches 1 MHz, though there is a reversal at lower temperatures, as shown in Fig. 7.

Resistivity

Both muscovite and phlogopite are hygroscopic. Any water betwen the mica layers will substantially reduce electrical resistivity, so careful drying is an essential element of mica processing.

It is the driving off of moisture which accounts for the rise in resistivity as temperature increases up to about 50°C. Beyond this point, however, resistivity falls. Fig. 8 shows the d-c characteristic for muscovite, which is higher than that of phlogopite by a factor frequently on the order of 100 at temperatures below 350°C. However, at higher temperatures the greater thermal stability of phlogopite comes into play, making the resistivity considerably higher than that of muscovite. This is the main reason phlogopite is usually specified for temperatures over 500°C. ■