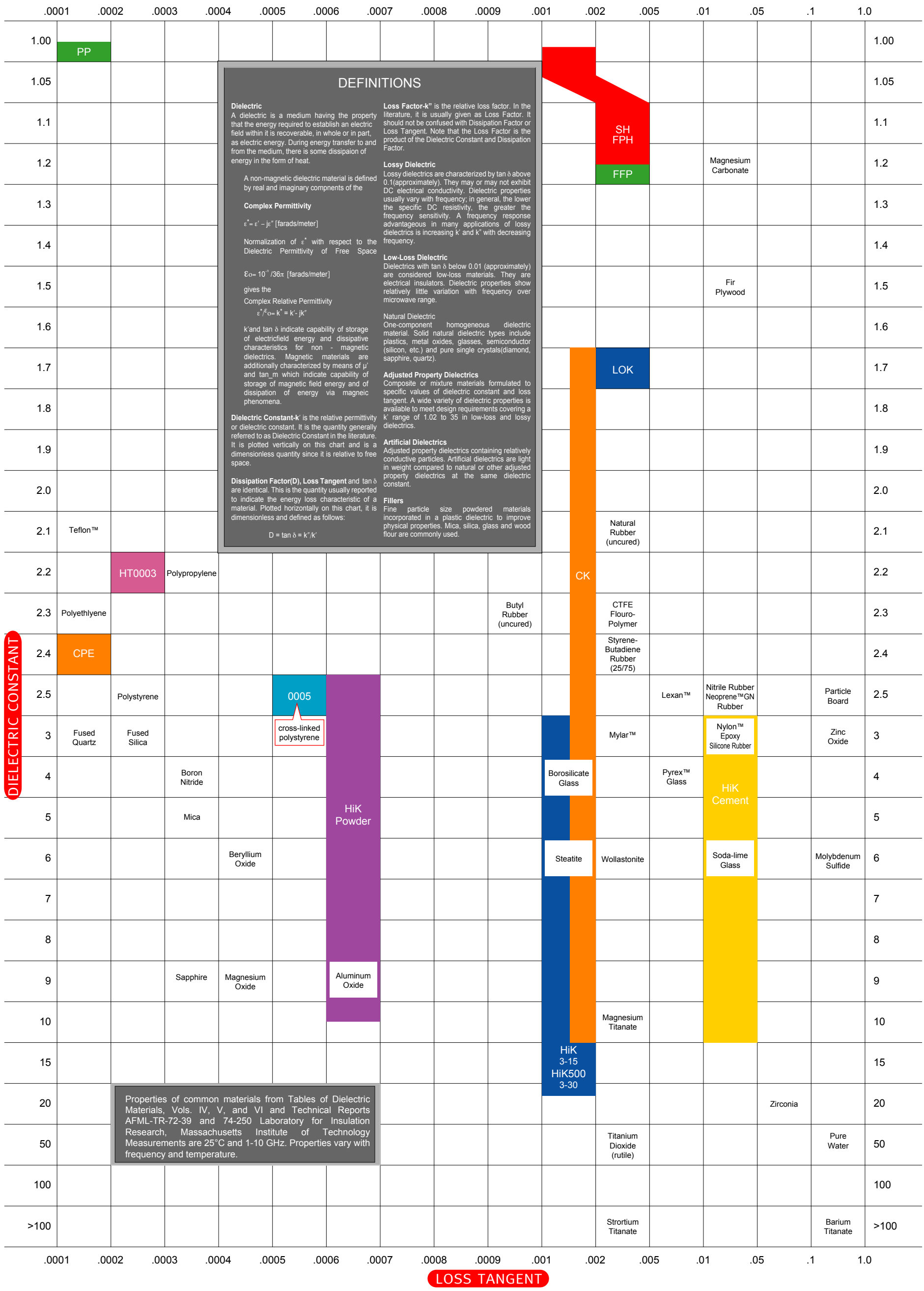
EMERSON & CUMING
MICROWAVE PRODUCTS

DIELECTRIC MATERIAL CHART

ECCOSTOCK® Low Loss Dielectrics & Other Common Materials



DEFINITIONS

Dielectric
A dielectric is a medium having the property that the energy required to establish an electric field within it is recoverable, in whole or in part, as electric energy. During energy transfer to and from the medium, there is some dissipaion of energy in the form of heat.

A non-magnetic dielectric material is defined by real and imaginary compnents of the

Complex Permittivity

$\varepsilon^* = \varepsilon' - j\varepsilon''$ [farads/meter]

Normalization of ε^* with respect to the Dielectric Permittivity of Free Space

$\varepsilon_O = 10^{-9}/36\pi$ [farads/meter]

gives the

Complex Relative Permittivity

$\varepsilon^*/\varepsilon_O = k^* = k' - jk''$

k'and tan δ indicate capability of storage of electricfield energy and dissipative characteristics for non - magnetic dielectrics. Magnetic materials are additionally characterized by means of μ' and tan_m which indicate capability of storage of magnetic field energy and of dissipation of energy via magneic phenomena.

Dielectric Constant-k' is the relative permittivity or dielectric constant. It is the quantity generally referred to as Dielectric Constant in the literature. It is plotted vertically on this chart and is a dimensionless quantity since it is relative to free space.

Dissipation Factor(D), Loss Tangent and tan δ are identical. This is the quantity usually reported to indicate the energy loss characteristic of a material. Plotted horizontally on this chart, it is dimensionless and defined as follows:

$D = \tan\delta = k''/k'$

Loss Factor-k" is the relative loss factor. In the literature, it is usually given as Loss Factor. It should not be confused with Dissipation Factor or Loss Tangent. Note that the Loss Factor is the product of the Dielectric Constant and Dissipation Factor.

Lossy Dielectric
Lossy dielectrics are characterized by tan δ above 0.1(approximately). They may or may not exhibit DC electrical conductivity. Dielectric properties usually vary with frequency; in general, the lower the specific DC resistivity, the greater the frequency sensitivity. A frequency response advantageous in many applications of lossy dielectrics is increasing k' and k" with decreasing frequency.

Low-Loss Dielectric
Dielectrics with tan δ below 0.01 (approximately) are considered low-loss materials. They are electrical insulators. Dielectric properties show relatively little variation with frequency over microwave range.

Natural Dielectric
One-component homogeneous dielectric material. Solid natural dielectric types include plastics, metal oxides, glasses, semiconductor (silicon, etc.) and pure single crystals(diamond, sapphire, quartz).

Adjusted Property Dielectrics
Composite or mixture materials formulated to specific values of dielectric constant and loss tangent. A wide variety of dielectric properties is available to meet design requirements covering a k' range of 1.02 to 35 in low-loss and lossy dielectrics.

Artificial Dielectrics
Adjusted property dielectrics containing relatively conductive particles. Artificial dielectrics are light in weight compared to natural or other adjusted property dielectrics at the same dielectric constant.

Fillers
Fine particle size powdered materials incorporated in a plastic dielectric to improve physical properties. Mica, silica, glass and wood flour are commonly used.

Properties of common materials from Tables of Dielectric Materials, Vols. IV, V, and VI and Technical Reports AFML-TR-72-39 and 74-250 Laboratory for Insulation Research, Massachusetts Institute of Technology Measurements are 25°C and 1-10 GHz. Properties vary with frequency and temperature.

TYPICAL PROPERTIES

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