

The Effect of Nuclear Radiation Exposure to RT/duroid® PTFE-Based Composites

The radiation resistance of RT/duroid® materials is of concern in space applications where microwave devices or antennas will be exposed to nuclear radiation.

RT/duroid materials are based on polytetrafluoroethylene (PTFE) combined with glass microfiber or ceramic filler. In either case, the component most susceptible to nuclear radiation damage is the PTFE. Because of the low cohesive forces between PTFE molecular chains, a polymer must be of very high molecular weight in order to realize the desired mechanical properties.

The primary effect of radiation on PTFE is the reduction of molecular weight by breaking the large polymer molecule into smaller parts. Oxygen is essential to some of the possible radiation induced reactions. Thus the damage due to radiation is minimized in an oxygen-free environment such as space.

The effect of molecular weight reduction is primarily on mechanical properties. There will be an increase in brittleness. Tensile strength, modulus and elongation are all reduced.

It has been reported that the mechanical changes in PTFE appear to depend on the total radiation dose and to be independent of dose rate. The dielectric properties are affected by electrical charge distributions in the resin which decay with time, and thus the dose rate is important.

During irradiation the dielectric constant and loss factor will be temporarily increased. The effect of radiation on these properties is less at elevated frequencies such as would be encountered in microwave applications.

The degree to which PTFE is affected is essentially a function of the amount of energy absorbed regardless of the identity of the radiation. That is, beta, gamma, X-ray, etc. have about equivalent effect. The radiation dose unit usually employed in radiation studies is the rad. One rad equals 100 ergs/grams.

The following is a summary of radiation doses in rads related to damage levels.

	In Air	In Vacuum
Threshold	2-7x10 ⁴	2-7x10 ⁵ or more
50% tensile strength	10 ⁶	10 ⁷ or more
40% tensile strength	10 ⁷ or more	8X10 ⁸ or more
Retain 100% elongation	2-5x10 ⁵	2-5x10 ⁶

Frequently the dose rate of 10 rads/hour is quoted for the Van Allen Radiation Belt. At this rate PTFE could operate for 5 to 50 years before a thresholds level of damage would be detectable mechanically.

Since the primary function of RT/duroid® microwave laminates is electrical, with mechanical support usually provided by metallic components, the exposures cited above can be expected to be well below the point where electrical performance would be impaired. The resistance of PTFE to radiation damage is generally better than that of solid state electronic devices such as transistors.

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