Effects of particle size on the dielectric, mechanical, and thermal properties of recycled borosilicate glass-filled PTFE microwave substrates

ABSTRACT

Low dielectric loss and low-cost recycled borosilicate (BRS) glass-reinforced polytetrafluoroethylene (PTFE) composites were fabricated for microwave substrate applications. The composites were prepared through a dry powder processing technique by dispersing different micron sizes (25 µm, 45 µm, 63 µm, 90 µm, and 106 µm) of the recycled BRS filler in the PTFE matrix. The effect of the filler sizes on the composites' thermal, mechanical, and dielectric properties was studied. The dielectric properties of the composites were characterised in the frequency range of 1–12 GHz using an open-ended coaxial probe (OCP) connected to a vector network analyser (VNA). XRD patterns confirmed the phase formation of PTFE and recycled BRS glass. The scanning electron microscope also showed good filler dispersion at larger filler particle sizes. In addition, the composites' coefficient of thermal expansion and tensile strength decreased from 12.93 MPa and 64.86 ppm/°C to 7.12 MPa and 55.77 ppm/°C when the filler size is reduced from 106 µm to 25 µm. However, moisture absorption and density of the composites increased from 0.01% and 2.17 g/cm3 to 0.04% and 2.21 g/cm3. The decrement in filler size from 106 µm to 25 µm also increased the mean dielectric constant and loss tangent of the composites from 2.07 and 0.0010 to 2.18 and 0.0011, respectively, while it reduced the mean signal transmission speed from 2.088 × 108 m/s to 2.031 × 108 m/s. The presented results showed that PTFE/recycled BRS composite exhibited comparable characteristics with commercial high-frequency laminates.

Keyword: Recycled borosilicate; PTFE; Sintering; Permittivity; High-frequency; Substrates