Polymer-derived ceramic (PDC) is a new class of materials synthesized by thermal decomposition of polymeric precursors, which exhibit excellent properties, including high thermal stability, high oxidation/corrosion resistance and multifunctionalities. Due to these unique properties, PDC is considered as a promising candidate for fabricating high-temperature sensors for harsh environment applications. The overall objective of this dissertation is to develop a suitable material for high temperature sensor application in harsh environment.

The SiAlCN ceramics were synthesized using the liquid precursor of polysilazane and aluminum-sec-tri-butoxide as starting materials and dicumyl peroxide as thermal initiator. The solid-state NMR indicates that the SiAlCN ceramics have the SiN₄, SiO₄, SiCN₃, and AlN₅ units. The Raman spectra reveals that the SiAlCN contains “free carbon” with the two specific peaks of “D” and “G” at 1350 cm. and 1600 cm., respectively. The ordering degree of the “free carbon” increases with increasing pyrolysis temperature. The EPR results show that the defects in the SiAlCN are related to carbon with a g-factor of 2.0016±0.0006. Meanwhile, the defect concentration decrease with increasing sintered temperature.

The electric and dielectric properties of SiAlCN ceramics were characterized. The D.C. conductivity of SiAlCN ceramics dramatically increases with increasing sintered temperature. An “electric field concentration” model is proposed to explanation of the huge increase of electric conductivity. The temperature dependent conductivity indicates that the conducting mechanism is a typical semiconducting and follows Arrhenius equation with two different sections of activation energy of 0.57 eV and 0.23 eV. The dielectric properties of SiAlCN ceramics reveal that the dielectric constant and loss increase with increasing temperature due to the space charge effect and increasing of conductivity of SiAlCN ceramics, respectively.

The SiAlCN ceramic sensor is fabricated by using the micro-machining method. The high temperature wired bonding issue is solved by the integrity embed method (IEM). The Wheatstone bridge circuit is well designed by considering the relationship between the matching resistor and the SiAlCN sensor resistor. It is found that the maximum sensitivity can be achieved when the resistance of matching resistor equal to the SiAlCN sensor. The SiAlCN ceramic sensor can work well up to 600 °C with a high sensitivity of 15 mV/K.

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The public is welcome to attend.