Preface

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It has been well known that adding small amount of filler particles into matrix composite material can strongly influence the latter's mechanical, thermal and electrical properties. During the past decade, the huge demand in composite industry for materials with high performance at an economical cost has led to a sound development of a new generation of particle filled composites. The practical reasons for the use of fillers are summarised as:

a stiffen the matrix

b regulate coefficient of thermal expansion and thermal shrinkage of the matrix material

c improve heat resistivity

d reduce creep of material

e increase strength properties of polymer matrix material

f modify permeability behaviour to gases and liquids

g improve electrical properties

h modify rheological properties

i lower cost of manufacturing.

The guest editors are pleased to introduce this special issue of *the International Journal of Materials and Structural Integrity* that focuses on current advances in 'particle filled composites: experimental and computational mechanics'. In this special issue, seven articles present cutting edge results covering a wide spectrum of particle filled composites both experimentally and theoretically.

The seven articles could be divided into two groups. The first group experimentally explores mechanical, electrical and thermal properties of particle filled composites while the second group investigates stress and strain behaviour of composites materials numerically.

The work done by Takeda et al. examined the compressive behaviour of multi-walled carbon nanotube (MWNT)/polymer composites. MWNT consist of multiple rolled layers of graphite, and are known for high stiffness, strength and current carrying capacity. The investigation shows that Young's modulus increases monotonically with increasing nanotube content at room temperature and 77°K. Reinforcing efficiency of MWNT at 77°K is higher than that at room temperature for Young's modulus in compression. By incorporating different percentage of $Ba(Zn_{1/3}Ta_{2/3})O_3$ (BZT) ceramic filler into PTFE matrix, James et al. studied the effect of BZT ceramic filler content on the microwave dielectric properties of the PTFE composites in microwave region. It is suggested that PTFE/$Ba(Zn_{1/3},Ta_{2/3})O_3$ composite substrate exhibits a dielectric constant of 6.2 together with loss tangent of 0.003 at X-band at optimum filler loading (76 wt%). The temperature coefficient of dielectric constant of the composite samples is observed to be in the higher side (>–116 ppm/°C). Abt et al. investigated the influence of fully or partially condensed polyhedral oligomericsilsequioxanes (POSS) cages on the properties of engineering thermoplastic-based nanocomposites. It was found that good dispersion at the nanoscale level can be achieved with addition of some functionalised POSS, leading to a remarkable increase of the thermal decomposition temperature under nitrogen atmosphere. In terms of thermal stability, the best performance was obtained when PMMA was mixed with tsp-POSS, and the thermal stability of POM dramatically increased upon the addition of apib-POSS.

Tarleton et al. simulated the strain field in an ATH-PMMA composite by assigning appropriate linear elastic material law to each integration point by comparing its location to a microstructural image obtained from an SEM. Their results were verified by experimental data. The article shows a possibility to model a microstructure when a clear image is not available provided statistical size distribution data is available. The article by Marur presents an analytical model to predict tensile strength of syntactic foams (hollow spherical inclusions typically embedded in a polymeric matrix) by analysing the influence of interface strength and stress concentration due to the inclusion. Nadot-Martin et al. presented a non-classical multiscale framework 'morphological approach' (MA) to model the non-linear behaviour of highly-filled composites. By treating damage as sequence of interfacial events, this framework simplified the treatment of time-dependent behaviour for highly-filled composites. MA provides a new way to characterise viscoelasticity of composite materials. Basaran and Gunel present a new multi-particle unit cell model of PMMA/ATH composite with different volume fractions, which was employed to study the influence of interphase properties and inter-particle distance on elastic modulus.

The seven papers presented in this special issue provide rich spectra of novel activities and advances in particle filled composites. The rapid growth of activities in composites industry worldwide is examining new ideas, developing new materials and modelling methods for material characterisation. The next decade will clearly enable composite material with special characteristics beyond current capabilities.