Editorial corner – a personal view

Polymer-based functionally graded materials (FGMs): potential and challenges

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Functionally Graded Materials (FGMs) are a class of engineered materials characterized by a spatial variation of composition and microstructure aiming at controlling corresponding functional (i.e. mechanical, thermal, electrical, etc.) properties. The tailored gradual variation of microstructural features may be obtained through non-uniform distributions of the reinforcement phase(s) with different properties, sizes and shapes, as well as by interchanging the role of reinforcement and matrix materials in a continuous manner. Various approaches are used to fabricate FGMs: bulk (particulate), preform, layer and melt processing techniques as well as ink-jet printing of different monomers followed by UV curing. These materials can be designed for specific functions and applications with a broad range of outlets in transportation, (bio)mechanical, civil or nuclear engineering, as well as sensor technology, tribology, optics, electronics or magnetics.

FGMs originally found widespread applications as metal-ceramic composites, in which there is a gradual microstructural transition from a ceramic rich to a metal rich region. Then, interest has emerged in the field of polymer-based FGMs, in particular for graded fibre composites, cellular structures (foams) or interpenetrating polymer networks.

Actually, organic structural composites and plastic foams present an interesting potential to design FGMs. On one hand, polymer composites are theoretically ideal materials that would permit to tailor reinforcement as a function of the applied stress

field. By distributing a fixed amount of fibres having a well-mastered orientation according to fraction of load to carry, the graded composite may provide better performance. On the other hand, cellular plastics often naturally have a gradient of microstructure through the part cross-section, due to the processing technologies used (e.g. injection, extrusion or rotational moulding). The challenge is however to be able to vary gradually and continuously the material properties not only through the thickness but also along the part length or width (i.e. in 3D). The textile technology may contribute to address these issues successfully in the case of structural composites. In the case of cellular polymers, the processing technology control remains a key issue, which requires further intensive research efforts at a laboratory scale. The final challenge would be to develop manufacturing techniques to produce such functionally graded polymeric parts under industrially viable conditions (scale-up, mass production, repeatability, reliability, cost-effectiveness).

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