Preface to the Special Issue on Smart Materials

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Materials have played a pivotal role from time immemorial in man's survival, progress and development. Over the years, new materials have appeared on the horizon influencing/revolutionizing the way we think, act and live.

Smart materials are those materials that have the unique capability to respond to their environment or external stimuli with a change in their shape or key material properties. While there is a host of smart materials, the predominant among them are shape memory materials. Shape memory materials are a class of smart materials (metallic/ceramic/polymeric) that respond to a change in temperature with a change in shape. Among shape memory materials, shape memory alloys that are basically metallic are well studied. Shape memory alloys exhibit many unique properties, the most noteworthy among them being shape memory effect and superelastic effect. The first practical applications of Ni–Ti alloys were found to be in dentistry (orthodontic archwires) and aeronautical engineering (pipe couplings in fighter aircraft). This spurred a flurry of activities in Ni–Ti shape memory alloys as well as research on other shape memory alloys, such as Fe-base, Cu-base and rare-earth-base shape memory alloys. But till date Ni–Ti alloys reign the roost in terms of the number of research papers published, the number of products developed and the number of patents filed. Even though research on Ni–Ti alloys is still going on, it seems to have reached a point of saturation as almost every conceivable topic or area seems

to have been explored. This has led to researchers focusing their attention on hitherto unexplored alloys, such as Nickel-free and rare-earth shape memory alloys, etc. The time has now come to look beyond the conventional or existing shape memory alloys.

There are also ample justifiable reasons for looking beyond Nitinol. Developing Ni–Ti SMAs is beset with problems. Though Nitinol has attractive functional and mechanical properties, it also suffers from drawbacks, such as lower transformation temperatures, difficulty in production and processing, degradation of properties with continued usage in service (functional fatigue), nonlinearity of properties, higher cost, etc. Obviously, this spurred the development of SMAs other than those based on Ni–Ti. It is also a challenge to develop SMAs not based on Ni–Ti, with shape memory characteristics that are on par with Ni–Ti alloys. Although hundreds of papers have been published over the past few decades on different facets of Ni–Ti SMAs, there are many aspects of other shape memory alloys that still remain unexplored. Even the topics of shape memory polymers, smart gels and shape memory ceramics have also been in vogue only in recent times.

While the non-NiTi SMAs have not found biomedical applications, there is a trend these days to go in for biocompatible and corrosion-resistant coatings to overcome this limitation and to enhance their range of applicability by improving upon their biocompatibility and corrosion resistance. There are also alternatives to Ni–Ti SMAs, i.e. ferromagnetic shape memory alloys, with a different driving force and mechanism of operation and with an added advantage of operating even in widely varying ambient/service conditions.

This special issue covers a variety of important and current topics pertaining to shape memory alloys/smart materials, such as ferromagnetic shape memory alloys, modelling and deformation behaviour of Ni–Ti SMAs,

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thermal characteristics of Cu-based shape memory alloys, severe plastic deformation of Cu-based SMAs to produce nano-crystalline shape memory alloys, thermomechanical processing of Fe-based SMAs, functional fatigue behaviour of Ni–Ti–Cu SMAs, shape memory composites, severe plastic deformation and magnetic properties of Ni–Fe–Ga SMAs, laser processing of Cu-based SMA bimorph micromirror and review of Ni–Ti thin films.

Trust the articles contained in this special issue will stimulate the interest of researchers working in these areas to delve deeper into the respective fields.

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