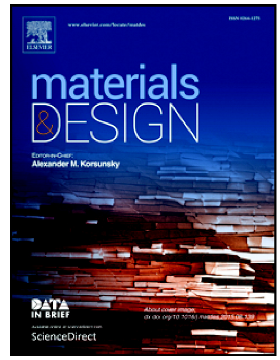


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# Functionally graded shape memory alloys: design, fabrication and experimental evaluation

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**Abstract**
Functionally graded shape memory alloys have the advantage of combining the functionalities of the shape memory effect and those of functionally graded structures. By proper design, they can exhibit new and complex deformation behaviour that are unmatched in uniform shape memory alloys. One obvious advantage of functionally graded shape memory alloys is their widened transformation stress and temperature windows that provide improved controllability in actuating applications. This paper reports on the concept, fabrication, experimentation and thermomechanical behaviour of several designs of functionally graded NiTi alloys, including compositionally graded, microstructurally graded and geometrically graded NiTi alloys, and the various techniques that may be used to create these functionally graded materials. It is found that the property gradients created along the loading direction or perpendicular to the loading direction produce distinct thermomechanical behaviours. The property gradient along the loading direction provides stress gradient over stress-induced transformation, which can be adjusted by the property gradient profile. The property gradient through the thickness direction of plate specimens and perpendicular to the loading direction provides four-way shape memory behaviour during stress-free thermal cycling after tensile deformation.

**Keywords**: Shape memory alloy (SMA); NiTi; martensitic transformation; functionally graded material (FGM); pseudoelasticity; heat treatment

## 1. Introduction

Shape memory alloys (SMAs) are a unique group of materials that have the ability to recover from large deformation well beyond the normal elastic strain limit of metals. This behaviour is associated with a thermoelastic martensitic phase transformation from a parent phase austenite (A) to a product phase martensite (M). This property renders the material the ability