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# Mechanical meta-materials: beyond conventional property limits

Meta-materials have attracted significant interests over the past decades due to their unique properties for industrial applications. Some meta-materials, such as Sn-BaTiO3 (BT)[1, 2], ZnAl-BaTiO3 [3, 4] (Metal matrix composites), are classed as metal matrix composites (MMCs) and have been demonstrated to have ultra-high stiffness due to the inclusion of BT particulates which undergoes a volume-change phase transformation. The mechanism responsible for this is derived from a constraint caused by the metal phase that surrounds the BT particulates in MMCs. The stress state of the two phases and their interaction under the combination of stress and thermal sources have also been revealed based on high energy X-ray diffraction measurement of bulk samples [5]. By using thermally mismatched materials, the two phases will behave differently during cooling process, resulting in a constraint on the ceramic particulates. Under this condition, the ceramic particulates will as expected store elastic energy at an equilibrium state. When non-equilibrium state presents during phase transformation, the stored energy will be released and this state will also be stabilized by the constraint from surrounding metals. Given the sufficient large energy stored in the inclusion, it may drive the composite to display ultra-high or even negative stiffness when an external stress is applied.

However, restrictions remain in MMCs due to the limited temperature range over the stress-induced phase transition in BT inclusion. Our work will try to explore the mechanism of the structural coupling between the two phases based on BT encapsulated MMCs and provide an insight for broadening this limited temperature range by changing the negative stiffness inclusion. Ex-situ mechanical measurements on BT have been performed at various frequencies. By doing this, the mechanical behaviour of BT will be directly observed and confirmed and is essential for identifying the related elastic properties in MMCs.

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