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Material and process development of thin-film shape memory alloy for MEMS actuator

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In this work we discuss the design and fabrication of a cantilever that may be actuated by utilizing the martensite to austenite phase transformation of a sputtered thin film of equiatomic NiTi shape memory alloy (SMA). The cantilever devices were fabricated on a silicon wafer using standard micro fabrication techniques, and may therefore be applicable to Micro-Electro-Mechanical Systems (MEMS) switch or actuator applications. This paper details the development of a co-sputtering process to yield a SMA film with controllable composition of Ni₅₀Ti₅₀ and transformation temperature around 60°C. Shape memory effects were characterized using Differential Scanning Calorimetry (DSC), for which we demonstrated martensite-austenite phase change at 57°C for 1-3 μm films, annealed at 600°C. We used wafer stress versus temperature measurements as additional confirmation for the repeatable measurement of reversible phase transformation peaking at 73°C upon heating. Up to 62 MPa was available for actuation during the thermally induced phase change. After exploring multiple approaches to a frontside wafer release process, we were successful in patterning and fabricating freestanding NiTi cantilevers that exhibited out of plane curling upon heating.

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Smart temperature responsive polymers with LCST at fever temperature

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The synthesis and development of smart polymers that can respond to external stimuli such as pH, temperature and light has been the main focus of current research. The temperature responsive materials with low critical solution temperatures (LCST) in the physiological range (30-40°C) attract much attention due to their potential biomedical applications and drug delivery systems. Poly(N-isopropyl acrylamide) (PNIPAM) has been the most studied temperature responsive homo-polymer exhibiting LCST in water around 32°C which is close to the lower end of the physiological range. The efforts have been made to tune the LCST of PNIPAM to around 37°C by variation in hydrophilic or hydrophobic co-monomer content, for different biomedical applications.

The lecture presented here discusses the synthesis and characterisation of potentially biocompatible and biodegradable smart polymeric materials exhibiting LCST within 38-40°C, known as fever temperature. It will first demonstrate the synthesis of a novel temperature responsive water-soluble glycopolymer via copper wire-catalysed click-polymerisation with an LCST at 39°C. Poly(N-vinylcaprolactam) (PNVCL) also exhibits an LCST in aqueous solution. PNVCL prepared by classical free radical polymerisation exhibits an LCST at 33°C. The lecture will then demonstrate that the application of RAFT for the polymerisation of N-vinyl caprolactam using a range of custom synthesised RAFT agents will produce PNVCL exhibiting LCST within the range of 38-40°C. The investigation of the cloud point of the aqueous solutions of these smart materials by optical microscopy and UV-Vis spectroscopy will also be discussed.

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