Laser 3D printing of micro-scale graded shape memory components for in-vivo actuated medical devices

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Shape memory alloys (SMA's) are a class of active materials that can be deformed at low temperatures and return to their original state under the influence of appropriate thermal or stress conditions. During this process, these materials generate a substantial amount of strain or force, making them suitable candidates for the fabrication of actuators. Nickel-Titanium (NiTi) SMA's are particularly interesting owing to their biocompatibility, resistance to corrosion and fatigue and can have a transition temperature (the temperature at which the material returns to its initial state) close to body temperature.

The idea of the project is to fabricate SMA components at a scale of 10's of microns using laser-driven processes such as laser-induced forward transfer (LIFT) wherein laser pulses are used to sequentially print thin 'sub-voxels' of metal onto a substrate. By depositing sub-voxels of different metal (nickel, titanium and copper) a fully functioning voxel will be fabricated. The transformation temperature of the functionally graded SMA component changes by varying the composition of the materials thereby widening the transformation window [1]. As with LIFT, the process is driven by the phase changes at the interface between the support substrate and thin layer of donor material and requires precise control of process parameters such as laser fluence, donor layer thickness and distance between the substrates [2].

Interdiffusion within and between the deposited sub-voxels will be obtained by using thermal treatments to provide localised control of composition for the fabricated microstructure. By altering the laser parameters, a scanning laser will be used to spatially distribute the SMA properties depending upon the requirement.

In this talk we present the initial results of LIFT of nickel and titanium obtained using a 355nm Q-switched Nd: YAG nanosecond laser. Further investigation of the process parameters will be done to obtain precise control to produce high quality voxelated structures.

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[2] Serra, Pere, and Alberto Piqué. (2019) Laser-Induced Forward Transfer: Fundamentals and Applications.,Advanced Materials Technologies 4.1,1800099

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