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Author: Ms. Tiziana Biasutti
Politecnico di Milano, Italy, tiziana.biasutti@polimi.it

Mr. Paolo Bettini
Politecnico di Milano, Italy, Paolo.Bettini@polimi.it
Dr. Adelaide Nespoli
Consiglio Nazionale delle Ricerche (CNR), Italy, adelaide.nespoli@cnr.it
Dr. Antonio Grande
Politecnico di Milano, Italy, antoniomattia.grande@polimi.it
Dr. Tanya Scalia
Italian Space Agency (ASI), Italy, tanya.scalia@asi.it
Dr. Marta Albano
Agenzia Spaziale Italiana (ASI), Italy, marta.albano@asi.it
Prof. Bianca Maria Colosimo
Politecnico di Milano, Italy, biancamaria.colosimo@polimi.it
Prof. Giuseppe Sala
Politecnico di Milano, Italy, Giuseppe.Sala@polimi.it

3D PRINTING OF SHAPE MEMORY ALLOYS FOR COMPLEX ARCHITECTURES OF SMART STRUCTURES

Abstract

Shape Memory Alloys are materials used to design smart structures with intrinsic functional properties and improved efficiency. This is a key aspect of aerospace industry and make SMA good candidates in this field. One of the most diffused SMA is NiTiNOL which, however, has the strong limitation of poor machinability, so only simple shapes can be obtained. Additive Manufacturing processes allow to overcome this limit and to design complex shapes. Compared to other metallic materials, the optimization of the process is complicated because, beside mechanical properties and presence of defects, considerable attention needs to be dedicated to the material functionality. The high temperatures of the process significantly affect the material properties, leading to possible evaporation of Ni and formation of precipitates. The paper is focused on the optimization of process parameters to ensure optimal pseudo-elastic behaviour, which is essential for the design of structural dampers. This was accomplished starting from simple structures and then designing a damper that couples the pseudoelasticity of NiTi with load support capacity.
A pseudoelastic powder (50.8% at. of Ni) was initially characterized. This was performed through the observation of SEM images, DSC, XRD, and EBS. After that, some cubic samples were manufactured, with the dimension of 3 x 3 x 5 mm^3 and 3 x 3 x 18 mm^3. A set of different power densities and scan speeds were used to find the best set of process parameters. The specimens were firstly evaluated based on their density. Specimens with density higher than 99.5% were the ones with the best performances. On each sample were performed DSC analyses on as-built and treated specimens and mechanical tests. Moreover, tomography followed by microscope observations investigate the presence of defects associated with different manufacturing parameters.
The samples were tested in compression, with static cyclic loading at different strains, increasing it up to 8%. The residual strain for cyclic loading at 4% is less than 1%, so good recovery of the deformation was

shown. Moreover, numerical analyses that model the pseudoelastic behaviour in compression tests were implemented.

Finally, due to the good pseudoelastic performance obtained on simple specimens, an innovative concept of structural dampers with functional properties and complex shapes was preliminary designed.