METHOD FOR MANUFACTURING TI ALLOYS WITH ENHANCED STRENGTH-DUCTILITY BALANCE

KEYWORDS

- > Additive manufacturing
- > EBM
- > SLM
- > Titanium alloys
- > TA6V
- > Thermal process
- > Post-treatments

Collaboration type
Partnership
Research collaboration
License agreement

IP Status
Patent pending
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State of the Art

Titanium alloys and more specifically TA6V (or Ti-6Al-4V) are widely used in the aeronautic and biomedical sectors, mostly due to their optimized mechanical properties and biocompatibility. They are produced through complex thermo-mechanical cycles that confer high strength and good fatigue resistance. However, they are always suffering from a lack of work hardening. This limits the uniform elongation, but also the forming capabilities and energy absorption performances.

3D printing or additive manufacturing (AM) offers new opportunities, especially thanks to the almost unlimited freedom and versatility it offers for the final part geometries. Until now, the net shape parts obtained by AM do not exhibit an optimized microstructure compared to their wrought (forged, rolled, extruded) counterparts. Consequently, innovative heat treatments must be developed in order to improve the mechanical properties of 3D printed parts without altering their geometry.

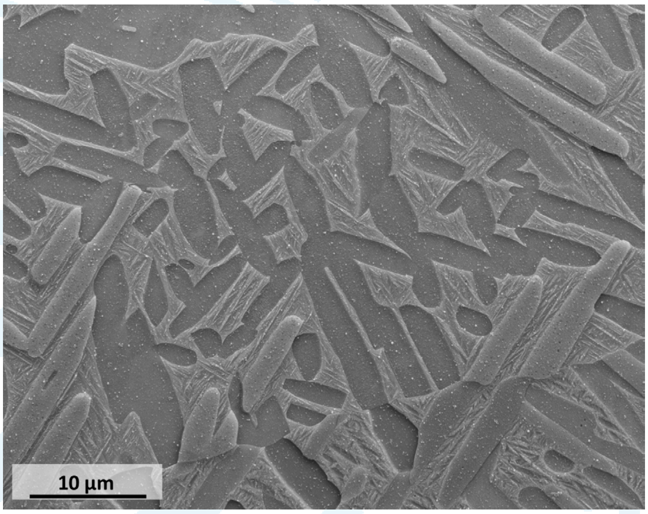

Fig.1. Dual-phase α and α' microstructures

The invention

The invention provides innovative post-process heat treatments that can be applied to near-net shape parts made up of Ti alloys built by AM. The properties obtained not only improve in a large way the as-built AM parts without altering their geometry, they even exceed the performances of the wrought Ti-6Al-4V material.

This innovative process leads to the production of dual-phase α/α' structures (Figure 1). The heat-treatment consists first in heat-treating the near-net shape part in the $\alpha + \beta$ Ti phase field in a specific range of temperature (generally between 875°C and 920°C). The part is then quenched in order to transform β phase and produce controlled volume fractions of martensite (α' phase).

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Key advantages of our technology

> Heat-treatment specifically developed for, but not limited to, near-net shape Ti parts ;

> Broad range of tensile properties obtained by varying the martensite fraction: large yield strength, large ductility, and high ultimate tensile strength ;

> Remarkable work-hardening behaviour inducing an improvement of the strength-ductility balance (Figure 2) that translates into excellent energy absorption capabilities (Figure 3) ;

> This new level of properties even exceeds that of conventional wrought Ti parts, making it very interesting for aeronautic and biomedical applications.

Applications

> Aerospace and aeronautic
> Biomedical and more specifically for orthopedic and dental implants

The inventors

Stéphane Godet is Professor at the Université Libre de Bruxelles and Head of the 4MAT Department. He holds a Master's degree in Materials Engineering (1998) from the Université catholique de Louvain and a PhD in Materials Engineering from the same university (2003). He became Assistant Professor at the Université Libre de Bruxelles in 2006 and is Professor since 2010. He has published over 140 peer-reviewed papers. His main research interests are the link between processing parameters, microstructure development and mechanical properties in inorganic materials.

Charlotte de Formanoir holds a Bachelor's Degree in Engineering (2011) and a Master's Degree in Chemical and Materials Engineering (2013) from the Université Libre de Bruxelles. She is presently PhD student at the 4MAT Department, Université Libre de Bruxelles.

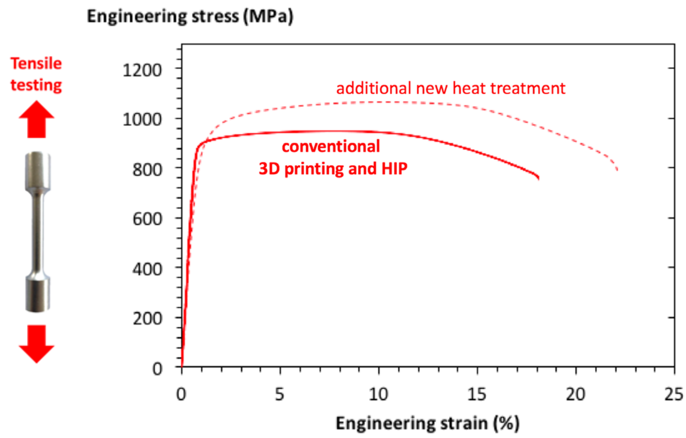

Fig.2. The new thermal treatment generates a higher work-hardening, resulting in a simultaneous increase in strength and ductility

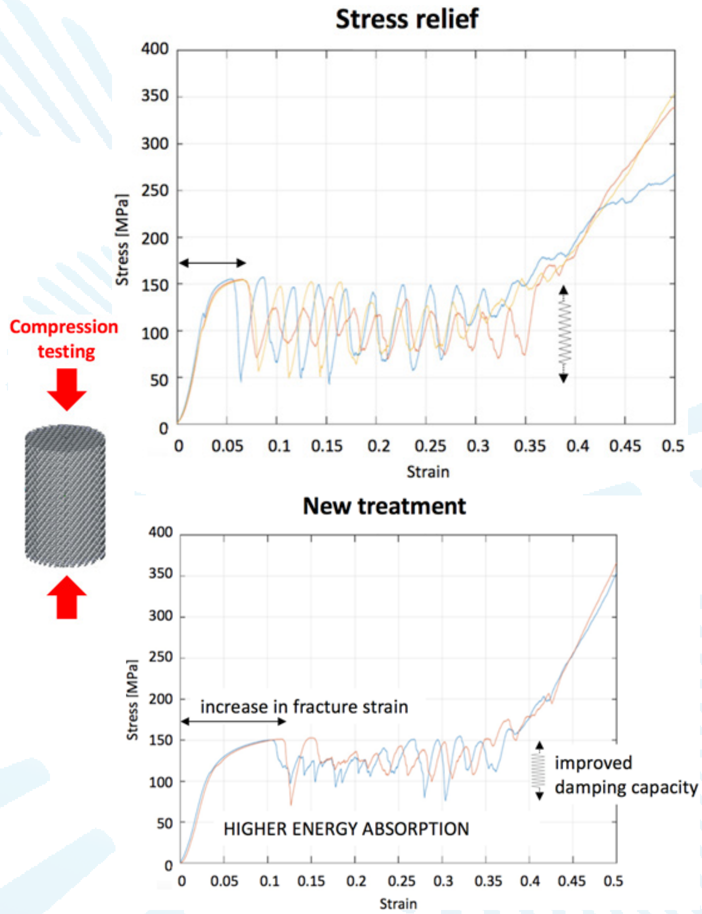

Fig.3. The new thermal treatment induces an increase in energy absorption during the compression of lattice structures.

Relevant publication

> A strategy to improve the work-hardening behavior of Ti–6Al–4V parts produced by additive manufacturing, de Formanoir C., Brulard A., Vivès S., Martin G., Prima F., Michotte S., Rivière E., Dolimont A., Godet S., Materials Research Letters 5:3 (2017), 201-208.

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