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Net-shape titanium grade 4 parts processed from titanium hydride powders

E. Carreño-Morelli, M. Rodriguez-Arbaizar, H. Girard, H. Hamdan, J.-E. Bidaux
University of Applied Sciences Western Switzerland, CH-1950 Sion, Switzerland

INTRODUCTION: The fabrication of titanium-based implants and medical devices usually needs several complex steps[1]. Net-shape processing by powder injection moulding (PIM[2]) of titanium hydride powders, which are cheaper and less reactive than titanium powders, can be the solution for breaking the cost barrier[3].

METHODS: Angular TiH_2 powder from AG Materials Inc., Taiwan, was used (Figure 1). The particle size distribution was determined by laser diffractometry in a Malvern Mastersizer 2000 apparatus (median size Dv50 = 20.26 µm).
Feedstocks for PIM were prepared with a binder consisting of 55 wt% paraffin wax (Sigma Aldrich GmbH, Buchs, CH), 35 wt% low density polyethylene (LDPE Riblene MP30, Polimeri Europa, I) and 10 wt% stearic acid (Sigma Aldrich GmbH). The solids loading was 60 vol%. Mixing was performed in a Coperion LUK 1.0 sigma blade mixer (Werner & Pfleiderer, Stuttgart, D) at 140°C for 4h. Polymer-powder granules were obtained by cooling down and crushing the mixture by slow shearing. Tensile test specimens were injection moulded in an Arburg 221K 350-100 machine (Arburg GmbH + Co KG, Lossburg, D).
Green parts were solvent debinded in heptane, then thermal debinded and dehydrided at 500°C under argon. Titanium parts were sintered at 1200°C under argon in a Nabertherm VHT08-16MO MIM furnace. Quantitative analysis was performed by fusion and infrared detection with LECO systems to establish the content of interstitial elements O, N, C in sintered parts. Tensile tests were performed in a Zwick 1475 machine.

RESULTS: Figure 1 shows both green (as injection moulded) and sintered dog bone parts. The shrinkage of about 19% is the result of binder removal and an additional contraction, which occurs during dehydriding of the TiH_2 base powder. The sintered density is 97.1% of the theoretical density.

Fig. 1: Titanium hydride powders, injection moulded and sintered titanium parts

The measured tensile properties are summarized in Figure 2 and Table 1. Together with a low content of interstitial elements (Table 1), the overall performance of PIM titanium meets the requirements of Ti grade 4.

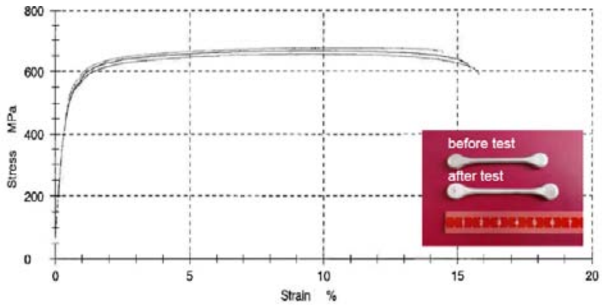

Fig. 2: Tensile behavior of PIM Ti parts from titanium hydride, 4h sintering at 1200°C

Table 1. Interstitial content and mechanical properties of PIM Ti parts from titanium hydride

	O [wt%]	N [wt%]	C [wt%]	density [%]	YS [MPa]	UTS [MPa]	elongation [%]
PIM-Ti	**0.30**	**0.027**	**0.065**	**97.1**	**519**	**666**	**15**
Ti grade 4	**0.4**	**0.05**	**0.08**	**100.0**	**480**	**550**	**15**

DISCUSSION & CONCLUSIONS: Titanium hydride powders are an attractive alternative for processing PIM Ti grade 4 parts. Their cost is about 50% of gas atomized Ti powders. Despite its angular shape (which is currently associated with low packing and high interparticle friction) and a necessary dehydriding step, good mechanical properties, shape preservation and reproducibility are achieved. Research is ongoing to evaluate the fatigue properties. PIM of Ti grade 2 parts would be feasible with powders of improved purity and optimized debinding and sintering conditions.

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