

---

# Bulk Ti and Ti6Al4V through Consolidation of Chips by Severe Plastic Deformation Methods

Jelena Horky<sup>1</sup>, Laszlo Sajti<sup>1</sup>, Peter Cengeri<sup>2</sup>, Michael Zehetbauer\*<sup>2</sup>, Bartosz Sulkowski<sup>3</sup>, Grzegorz Boczkal<sup>3</sup>, and Erhard Schafner<sup>2</sup>

<sup>1</sup>RHP Technology GmbH, Seibersdorf, Austria – Austria

<sup>2</sup>University of Vienna, Faculty of Physics, Wien, Austria – Austria

<sup>3</sup>Faculty of Non-Ferrous Metals, AGH University of Cracov, Krakow, Poland – Poland

## Abstract

In this work, the two most important Severe Plastic Deformation (SPD) methods - Equal Channel Angular Pressing (ECAP) and High Pressure Torsion (HPT) - were used for recycling and/or upcycling of titanium chips. Chips of thickness 0.1 to 0.2 mm were machined from pure Ti and Ti-6Al-4V. The grain size within the chips was 1 to 2  $\mu\text{m}$ , and revealed to be stable till temperatures of at least 500°C. For successful consolidation, efficient cleaning of the chips was crucial; using ultrasonic finger proved as the best method. After consolidation using different strains and temperatures, the samples were characterized by mechanical testing (microhardness, and torque for HPT), by texture analysis, and by optical as well as electron microscopy. Then the properties and microstructures of those samples were compared to that of their bulk counterparts.

Fig.1. Torque curves of Ti-6Al-4V processed by HPT at room temperature (2 turns at 2 GPa pressure), chip thickness 0.2 mm

In Fig. 1, the successful plastic (HPT) deformation is shown in a development of the torque without sharp load drops that would be observed if the sample slips. The bulk material shows a high and roughly constant torque already with smaller deformations, while for the consolidated sample this level is reached only beyond von Mises strains of about 30. Up to this value, all the processing is spent for progressive consolidation of the chips.

In conclusion, it can be stated that the consolidation and the recycling of chips using SPD occurs via their plastic deformation, not so much via pressure nor via diffusion, and can therefore be carried out at lower temperatures than, for example, sintering. It is important that the chips undergo plastic shearing and do not slide off each other. High processing temperatures, high deformation degrees and high pressures are advantageous for consolidation.

**Keywords:** Ti and Ti alloys, Chips Consolidation, ECAP, HPT

---

\*Speaker