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Damping Characteristics of Titanium- Titanium Boride Composite

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ABSTRACT

Titanium and its alloys exhibit excellent combination of physical and mechanical (high strength and toughness material) properties and have similar strength as steel but with a weight nearly half of steel, the Applications of Ti alloys to structural materials are limited to special uses so far, because they have problems of poor heat and wear resistance as well as their high manufacturing cost. In order to solve these problems and to apply Ti alloys widely to general structural materials, the powder metallurgy Technology, which enables the near-net-shape manufacturing, recently attracts great attention. In particular, the TiB dispersed Ti composites (TiB/Ti composites) manufactured. Titanium and Titanium boride composite through the different target volume percentages of TiB (20% and 40%) have been prepared in spark plasma sintering, hot iso static pressing and vacuum sintering process.he damping characteristics of the composite such as storage modulus; loss modulus tan delta determined using Dynamic Mechanical Analysis (DMA). The results are compared for each fabrications process.

Keywords: Ti- Titanium, TiB- Titanium Boride, DMA- Dynamic Mechanical Analysis, SPS-Spark Plasma Sintering, HIP-Hot Iso Static Pressing, VSP- Vacuum Sintering Process.

1. INTRODUCTION

Titanium and its alloys exhibit excellent combination of physical and mechanical (high strength and toughness material) properties and have similar strength as steel but with a weight nearly half of steel. Which have made them the material of choice in various aerospace, marine, Industrial, architectural, biomedical, sports, chemical and corrosion resistant applications. However, the Applications of Ti alloys to structural materials are limited to special uses so far, because they have problems of poor heat and wear resistance as well as their high manufacturing cost. In order to solve these problems and to apply Ti alloys widely to general structural materials, the powder metallurgy Technology, which enables the near-net-shape manufacturing, recently attracts great attention. In particular, the TiB dispersed Ti composites (TiB/Ti composites) manufactured. By the blended elemental method can markedly raise hardness and heat resistance of Ti owing to the hard and thermally stable TiB particles without reducing fatigue strength and toughness too much. Titanium 3and Titanium boride composite through the different target volume percentages of TiB(20% and 40%) have been prepared in SPS,VS,HIP process.In this laboratory you will be using a Dynamic Mechanical Analyzer (Model Q800, TA Instruments) to investigate how the storage modulus of varies with frequency and temperature. The linear viscoelastic properties of composite are dependent on both time and temperature. Usually, rheological measurements are made such that either the temperature or the frequency/time is held constant while the other parameter is varied. In the case of oscillation experiments in which the temperature is held constant and the frequency or time is varied, the data spans over a two to four decade range in frequency/time. By repeating such tests over a number of temperatures, one obtains a set of isothermal dependencies of, say, storage modulus (E') or loss modulus (E'') in shear versus frequency, w. If the material is thermo-heologically simple, then one can shift any of the linear viscoelastic parameters, e.g. E', E'', J', J'', η', η'', or G(t), J(t),along the time/frequency axis such that they are superimposed on one another to generate a master curve at a particular temperature.

2. EXPERIMENTAL PROCEDURES

2.1 DMA Procedure

Cut sample with known geometry and Load sample into clamp inside DMA furnace. Set start temperature, finish temperature, and Apply same cyclic strain through entire temperature range. DMA records material response to deformation and determines: E', E'', Tan Identify transition temperatures based on noticeable changes in curves.

2.2 **Testing method**

Cut samples of known size (10mm x 5mm x 0.3mm) Testing Parameters - 1% Strain, Frequency = 1Hz T = 30°C to 600°C Analyzed plots: Log E' vs T, Log E'' vs T & Tan Delta(δ) vs TDMA was used to determine elastic modulus properties of all six systems. DMA accepts several different forms of samples. Equipment available for this study required small rectangular samples approximately 10 mm long, 10 mm wide, and 0.100-2 mm thick. To meet this requirement, thin film samples on glass slides were created. Samples were prepared by the approach described above in nano indentation experimental procedures. For this technique, however, enough mixture was poured to cover the entire slide. Because the slides were approximately 25 mm wide this approach allowed cutting. DMA tests were performed on a Dynamic Mechanical Analyzer using RSA Orchestrator v6.58B2 software. Parameters set for tests included: 10 mm gap distance, Rectangular Tension/Compression geometry, strain-controlled test type. Sample geometry was input for each sample. Although the DMA was configured with two transducers, the maximum transducer load was 3500 grams so compression testing had to be manually stopped prior to sample breakage so that the transducer did not overload. Once the compression test completed, the stress vs. strain report produced by the software was observed and an initial static force used for dynamic testing was chosen. Given the stress limits, compression testing only served to indicate the proper initial static load.

Dynamic testing was performed on one to six samples for each system. Parameters were the same as for compression testing except test mode was "Dynamic Temperature Ramp Test", measurement type was "dynamic", 1.0Hz frequency, 30°C initial temperature, 600°C final temperature, 2.0°C/minute ramp rate, 0.1% strain rate, and initial static load of 100-250 grams. Initial static load was chosen to be 0.5% to 1% strain in the tensile testing results. The damping test on Ti-TiB composite are carried out Behavior of the Storage Modulus E',Loss Modulus E'',Tan Delta(δ) are discussed in this section.

3. RESULT AND DISCUSSION

DMA was performed to determine the bulk mechanical properties of composite. Prior to executing dynamic and static tensile/compression tests and to determine the optimal static initial load also. Dynamic testing results were processed by the computer software and provided as a plot of storage (elastic) modulus, loss modulus, and tan δ versus temperature.. The goal of using modulus results for direct comparison between the composites and the reference systems; and the primary result was evaluated at room temperature. Sample output from the DMA test of the Ti-TiB composite for a test that run to completion. The peak of the red tan δ curve provides the glass transition temperature of the composite. Buckled prior to reaching a maximum tan δ and the test had to be manually stopped. The midpoint value is taken as tan δ.

4. RESULT OF DYNAMIC MECHANICAL ANALYSIS

The valves obtained from the DMA in TA Instruments Q800 listed in the table are shown below:

Result obtained from dynamic mechanical analysis

TI AIIOY Composition	Frequency Hz	TIME Min	Temperature °C	Storage Modulus MPa	Loss Modulus MPa	Tan Delta

Process: Hotisostatics pressing at 1200 °C

Ti-20% TiB	1	The midpoint value are not obtained in the Ti- 20% TiB .since the DMA curve for tan delta is non linear fashion				
Ti-40% TiB	1	6.81	144.11	718314	718314	3.264

Process: spark plasma sintering at 1100 °C

Ti-20% TiB	1	The midpoint value are not obtained in the Ti- 20% TiB .since the DMA curve for tan delta is non linear fashion.				
Ti-40% TiB	1	13.15	271.44	788679	786258	8.178

Process: vacuum sintering at 1400 °C

Ti-20% TiB	1	The midpoint value are not obtained in the Ti- 20% TiB .since the DMA curve for tan delta is non linear fashion.				
Ti-40% TiB	1	6.81	144.11	1444460	1444460	1

The result obtained from DMA of all the comparatives are shown in fig 1-6

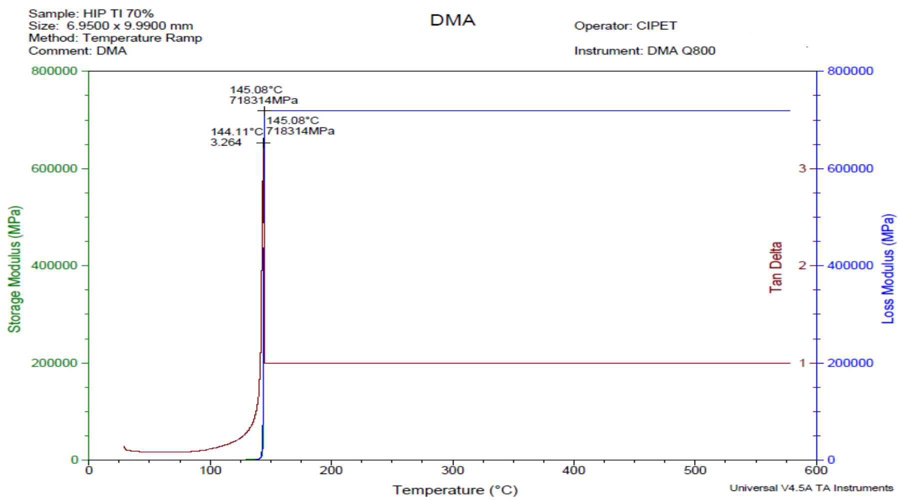

Fig 1.DMA dynamic test results for Ti- 40% TiB in Hot Isostatic Pressing

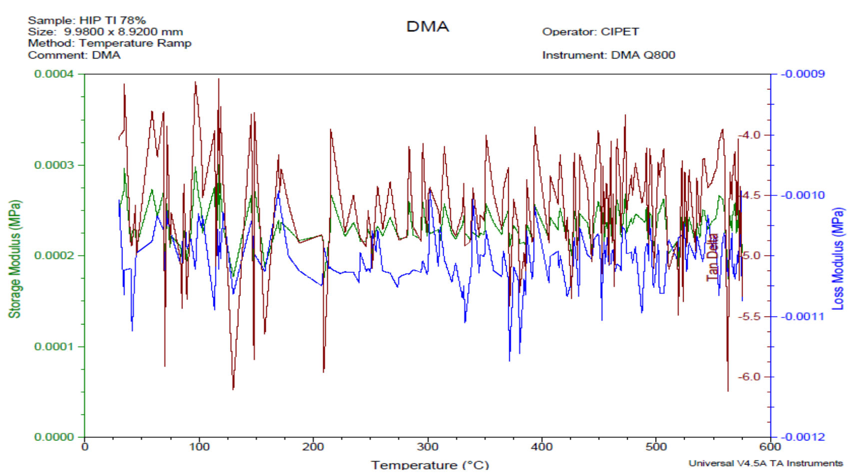

Fig 2.DMA dynamic test results for Ti- 20% TiB in Hot Isostatic Pressing

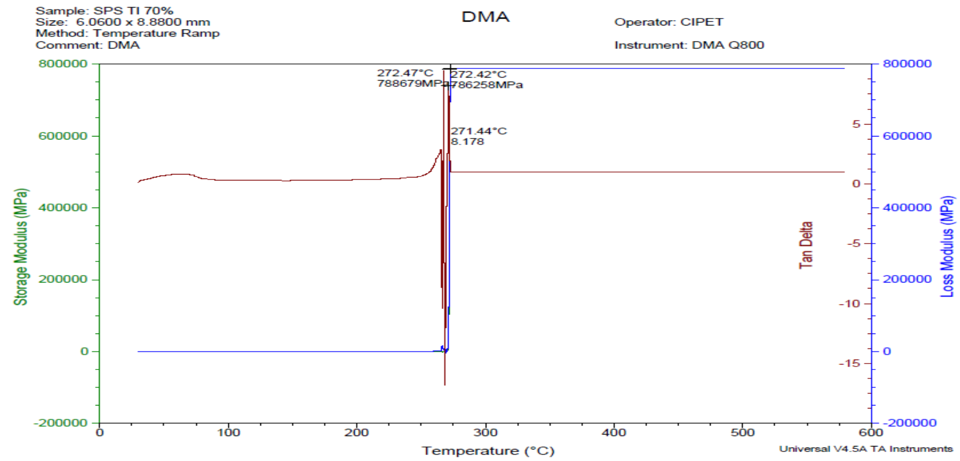

Fig 3.DMA dynamic test results for Ti- 40% TiB in Spark Plasma Sintering

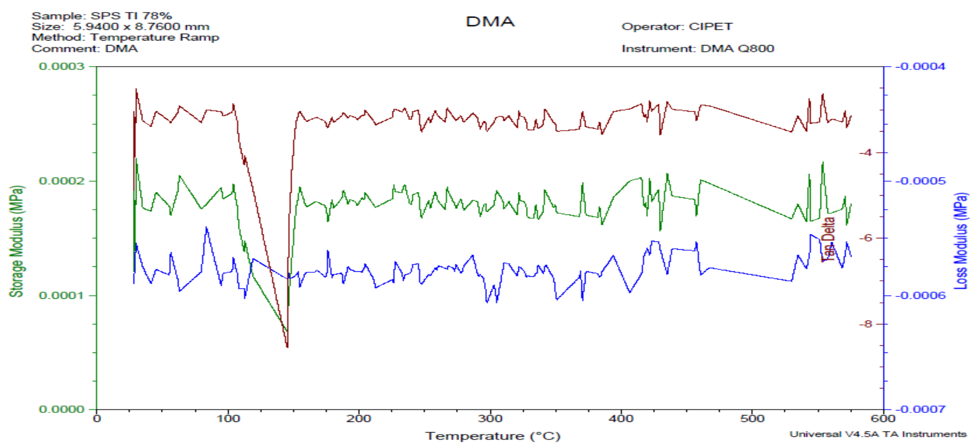

Fig 4.DMA dynamic test results for Ti- 20% TiB in Spark Plasma Sintering

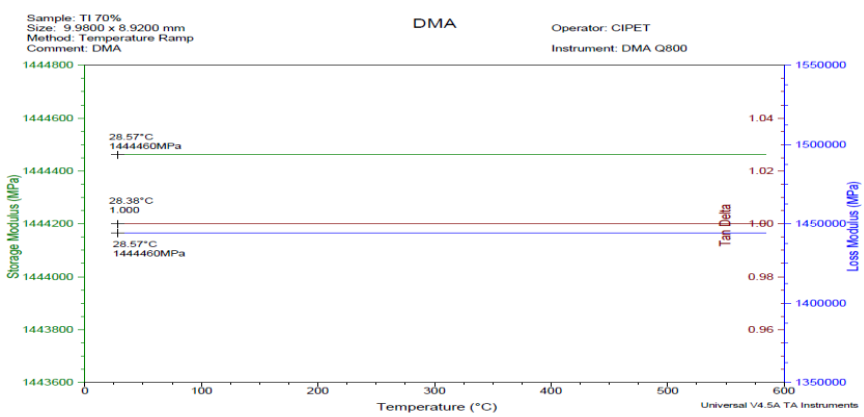

Fig 5.DMA dynamic test results for Ti- 40% TiB in Vacuum Sintering

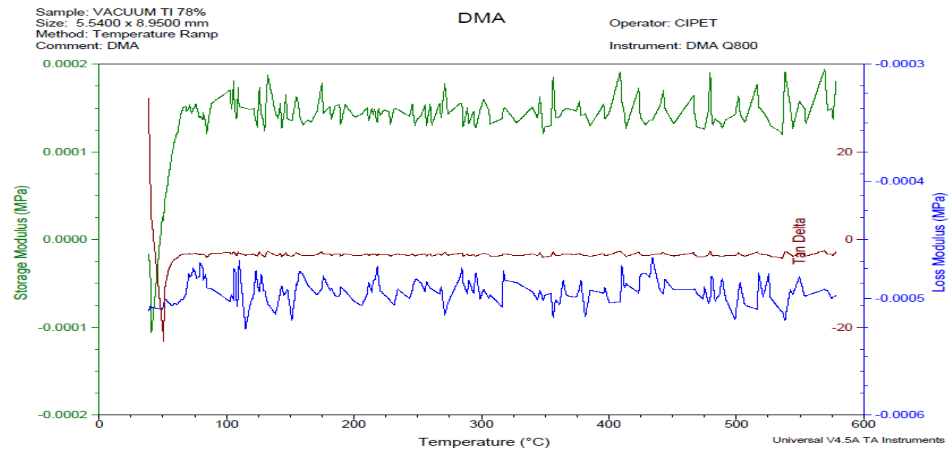

Fig 6.DMA dynamic test results for Ti- 20% TiB in Vacuum Sintering

4. CONCLUSION

The damping characteristics of Ti-TiB composite is experimentally found out: The following conclusions are arrived:

The Ti-TiB composite powders with 20% & 40% volume of TiB reinforcement have been processed by hot isostatic pressing, spark plasma sintering & vacuum sintering.

The storage modulus, loss modulus and tan delta of composite (having 40 vol % TiB) processed by spark plasma sintering have highest value than other methods.

Composite (with 40 vol % of TiB) is processed by spark plasma sintering pressing have highest damping force than other methods.The midpoint value are not obtained in the Ti- 20% TiB fabricated through all process since the DMA curve for tan delta is nonlinear fashion.

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