Influence of Vacuum Heat Treatments on Microstructure, Texture and Mechanical Properties of NiTa Alloy Fabricated by Laser Powder Bed Fusion for Sputtering Target Application

Cheng-Tse Wu[1], Markus Bussmann[1], Kinnor Chattopadhyay[2]

Corresponding author: kinnor.chattopadhyay@utoronto.ca

1. Department of Mechanical and Industrial Engineering, University of Toronto, 5 King's College Road, Toronto, Ontario, Canada M5S 3G8
2. Dean's Catalyst Professor, Department of Materials Science and Engineering, University of Toronto, 184 College Street, Toronto, Ontario, Canada M5S 3E4

The semiconductor industry uses a physical vapor deposition process, with a Nickel-Tantalum (NiTa) alloy sputtering target, to apply an amorphous NiTa thin film layer between the magnetic soft underlayer and substrate of a heat-assisted magnetic recording hard disk drive. Currently, the alloy sputtering targets are produced by a hot-pressing (HP) followed by hot isostatic pressing (HIP). In this study, we demonstrate an alternative process for producing the sputtering targets, using laser powder bed fusion (L-PBF) followed by vacuum heat treatment (VHT), to produce alloy targets with superior microstructural characteristics, that will produce better quality thin films. As well, the average microhardness value is reduced from 745 to 594 HV 0.2 as the result of recrystallization. Results indicate that VHT-treated L-PBF NiTa specimens exhibits a uniform equiaxed grain microstructure with smaller grain size (2.1±0.2 μm) than the traditional HIP-treated HP specimens (6.0±0.6 μm).

1. Introduction

Nickel Tantalum (NiTa) thin films are extensively used by the semiconductor industry to enhance the adhesion and thermal properties of the magnetic soft underlayer in heat-assisted magnetic recording (HAMR) hard disk drives [1]. These thin films are produced by physical vapor deposition (PVD) with a NiTa sputtering target. Traditionally, the sputtering target manufacturers employ a hot pressing (HP) process followed by a hot isostatic pressing (HIP) to form alloy powder into a dense and composition-homogenized structure [2, 3]. However, the HIP treatment is time-consuming and tends to deform parts, resulting in significant cost and material loss.

The recent rapid growth of additive manufacturing (AM) technologies offers an opportunity to overcome such a manufacturing challenge. One example of AM technologies is laser powder bed fusion (L-PBF), which utilizes single or multiple laser beams to selective melts the surface of a metal powder bed to produce nearly fully dense parts with high dimensional precision and mechanical properties which are comparable to those obtained by traditional manufacturing processes [4–7]. L-PBF of sputtering targets has significant potential, as it produces a part with much finer grain size and minimizes element segregation. While the L-PBF process could greatly reduce the metallurgical challenges of manufacturing sputtering target disks, the final mechanical properties of parts fabricated by L-PBF remain challenging. One of the major challenges is the formation of defects such as solidification cracks due to significant thermal gradients in regions adjacent to the heat-affected zone (HAZ), and the coefficient of thermal expansion (CTE) mismatch between the solidified part and baseplate, which is caused by rapid heating and cooling during L-PBF.