CHARACTERIZATION OF PLASMA SPHEROIDIZED AND POWDER BED FUSION PROCESSED COMMERCIALLY PURE NIOBIUM

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ABSTRACT

Accelerators are necessary for the fundamental study of matter and its origins. A critical component of accelerators are the niobium superconducting radio frequency (SRF) cavities, which are used to accelerate the particles. Because of the significant number of niobium SRF cavities required for each accelerator, innovative manufacturing techniques are needed to reduce fabrication costs and to ensure high quality cavities are produced. Recently, 3D Additive Manufacturing (AM) methods have been shown to reduce the cost and fabrication time of complex components using conventional metals. However, the high melting temperatures, sensitivity to interstitial impurities, and difficulty of obtaining suitable feedstock materials have limited the 3D printing of refractory metals. Recently, innovative Plasma Alloying and Spheroidization (PAS) techniques have been developed, which enable the production of high purity, spherical refractory metal powders. During this effort, the PAS processing of commercially pure hydride/dehydride (HDH) niobium was evaluated for producing suitable feedstock for subsequent 3D printing of accelerator components. Preliminary results have shown the ability to produce spherical niobium powder with significant improvement in flowability, and metallic impurity levels similar to wrought superconducting grade niobium, i.e., Residual Resistivity Ratio>300 (RRR300). In addition, interstitial impurity levels were reduced to levels below commercially available high purity niobium powder after post-PAS processing. Using the PAS niobium powder, Electron Beam – Powder Bed Fusion (EB-PBF) processing methods were used to produce 3D printed niobium samples for preliminary characterization. Tensile testing of AM produced samples from PAS niobium showed the mechanical properties were equivalent or superior to wrought niobium. Preliminary RRR testing showed AM samples produced with commercially pure, PAS niobium powder had values equivalent to AM samples previously produced with nuclear reactor grade niobium feedstock.

INTRODUCTION

Accelerators such as the Continuous Electron Beam Accelerator Facility (CEBAF) at Thomas Jefferson National Laboratory (JLab) are necessary for the fundamental study of matter and its origins. A critical component of linear colliders are the niobium superconducting radio frequency (SRF) cavities, which are used to accelerate the particles. Because of the significant number of niobium SRF cavities required for each collider (e.g. JLab has ~340 SRF cavities at a cost of $30K each), innovative manufacturing techniques