2.0 INTRODUCTION

The phenomenon of superconductivity has had a tremendous impact on the advancement of technology in many fields including medicine, electronics, motors, power, transportation and communication. Accordingly, the call to develop superconducting materials is strong and will remain so as the technology improves and becomes less expensive. Discovering or developing a superconducting material with a room temperature superconducting state is the ultimate challenge in superconductivity, but with the uncertainty of this ever being achieved, the current focus of much of the research, development and commercialization of superconductors is on YBCO.

From 1911, when superconductivity was discovered, until 1986, when a lanthanum cuprate ceramic material was found to be superconductive, there were no ceramic materials known to exhibit superconductivity. Even with the breakthrough of the first ceramic superconductor, the temperature at which this phenomenon occurred was still extremely low. The discovery of a YBCO superconducting material in 1987 brought about a great excitement within the scientific community. The idea that a material can conduct electricity free of resistance, at temperatures above 77 K, the temperature at which nitrogen liquefies, opened up the possibility for numerous advancements for electronic and wire technologies. The development of such devices, however, turned out to be a very difficult task. Among the major barriers are the inherent brittleness of YBCO and the high processing temperature required to produce the superconducting phase.

In order to comprehend the nature of YBCO superconductors and the obstacles they face in application, it is essential to have an understanding of the three main parameters that characterize superconductivity. The first of which, the critical temperature or transition temperature, indicates the temperature at which the material switches between the normally conductive state and the superconductive state. The second parameter, the critical magnetic field, indicates the maximum strength of the magnetic field that can be endured without completely destroying the superconducting state. Finally, the critical current density is the third parameter that characterizes superconductors, and it indicates the maximum amount of current that can flow through an area of the superconductor. These three parameters are the fundamental characteristics of YBCO with respect to its superconducting capabilities. To improve these and other properties, various processing techniques have been explored and used. Producing YBCO in different forms is essential in order to fabricate YBCO materials with the necessary properties for the desired applications. Achieving this, though, is not always a simple matter.

YBCO superconducting materials can be produced in thick and thin films or in bulk form. The processing techniques used to fabricate YBCO are typically the standard processes employed for producing ceramics and films. These include the standard ceramic powder processing methods, sol-gel and melt processing techniques to form the bulk YBCO ceramic, in addition to various deposition techniques to produce the thin and thick films of YBCO. Some modifications to these techniques have been developed to alleviate problems inherent to producing YBCO superconducting materials and to enhance the superconducting properties. As with all materials, the processing techniques will determine the material's properties to some extent and since the microstructure of YBCO can have a significant affect on its superconducting properties, the fabrication technique and the precision to which it is carried out is very important.

Even though powder processing can be a straightforward process, a few issues are present when ensuring the fabrication of quality YBCO powders. For example, maintaining a homogeneous mixture, preventing contamination by foreign substances, and inhibiting undesired side reactions between the precursors and other agents used during processing are a few of the concerning issues.

It is often desired for bulk YBCO ceramics to have few impurities and grain boundaries because these tend to impair the superconducting properties of the material. Melt processing is another bulk forming technique and is used to reduce and eliminate such material deficiencies. Essentially, melt texturing can produce bulk YBCO superconductors with improved properties compared to the other bulk forming techniques. However, one of the major obstacles associated with this method is the limited size in which the material can be produced.

YBCO as a ceramic material does not have the inherent mechanical properties metals have that make them easier to process and more durable in some applications. This limits the size that bulk and film materials can be produced. YBCO/Ag composites have been formulated to improve the ductility and strength of the superconducting material in an effort to increase the size restrictions.

The high processing temperatures required to produce superconducting YBCO have made the development of electronic devices difficult. Electronic devices require the deposition of YBCO films onto suitable substrate materials. The high processing temperatures cause interactions to occur between the film and substrate which generally degrade superconducting properties. Finding suitable substrates and developing new film deposition methods has lead to some successes in electronics. The current methods are however costly, and not available for large scale production.

The brittleness and the development of a continuous processing method are the major issues for the development of YBCO superconducting wires. YBCO depositions onto nickel based substrates have been successful to increase the ductility of the wire, but the lack of a continuous processing method has limited the length of YBCO wires that can be produced.

Bulk YBCO superconductors are primarily used in levitation applications, where they levitate a permanent magnet to perform some function. Thin and thick films of YBCO are generally used for electronic and wire technologies. The first application of YBCO superconductors was realized in bulk form for magnetic devices. Superconducting magnets are used in medical as well as energy storage devices. Magnetic resonance imaging (MRI) devices had been around before the discovery of superconducting YBCO, but the newer high temperature superconducting material reduced costs compared to earlier technology. While YBCO superconductors are suitable materials for many applications, complex designs and high operating costs of the cooling systems required for proper superconductor performance are the primary obstacles preventing broader implementation of systems utilizing YBCO superconductors.