In Situ Synchrotron X-ray Diffraction Study of Reaction Kinetics for Reactively Processed Mg/MgB_2 Metal Matrix Composites

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Introduction

Magnesium diboride is a recently discovered superconductor with a critical temperature of 39K [1] and other superconducting properties comparable to commercially available Nb_3Sn and high-temperature cuprate superconductors [2]. Mechanically, MgB_2 is a brittle ceramic and requires a ductile sheath or dispersion within a metal matrix for commercial applications. We have produced superconducting MgB_2 fibers *in situ* within a magnesium matrix by reacting commercially available boron fibers and magnesium liquid to form MgB_2 and subsequently solidifying the magnesium [3]. To gain a full understanding of this reactive process, reaction kinetics are studied *in situ* by using synchrotron x-rays.

Methods and Materials

Boron filaments (Goodfellow, UK) 100 μm in diameter were aligned within a titanium crucible (8-mm inner diameter, 8.5-mm outer diameter) and gas-pressure-infiltrated with magnesium at 800°C [3, 4]. The initial volume fraction of the filaments was 20%. The sample was enclosed within an evacuated quartz tube backfilled with 1/3 atm of argon. A custom infrared lamp furnace heated the sample to 950°C from the side to melt the magnesium and react it with the boron filaments within the titanium crucible. The reaction was monitored by exposing the sample to 65-keV x-rays with 30-second exposure times captured on a charge coupled device (CCD) camera (Photonic Science Limited, UK). Experiments were performed at DND-CAT beamline station 5-BM-D at the APS. Diffraction ring images were converted to 1-D intensity versus 2θ plots by using FIT2D software [5].

Results

The formation of MgB_2 was observed through the appearance of a diffraction ring (peak) (Fig. 1) after reaction at 950°C. The intensity of the peak increased with time corresponding to a higher degree of reaction in the fibers (Fig. 2).

Discussion

These preliminary results show that the reaction of $Mg + 2B = MgB_2$ can be studied with synchrotron x-rays and CCD on magnesium-infiltrated boron fibers in a titanium crucible. Future experiments will monitor the reaction of boron fibers and powders having different diameters with magnesium liquid and vapor at temperatures between 700 and 1100°C.

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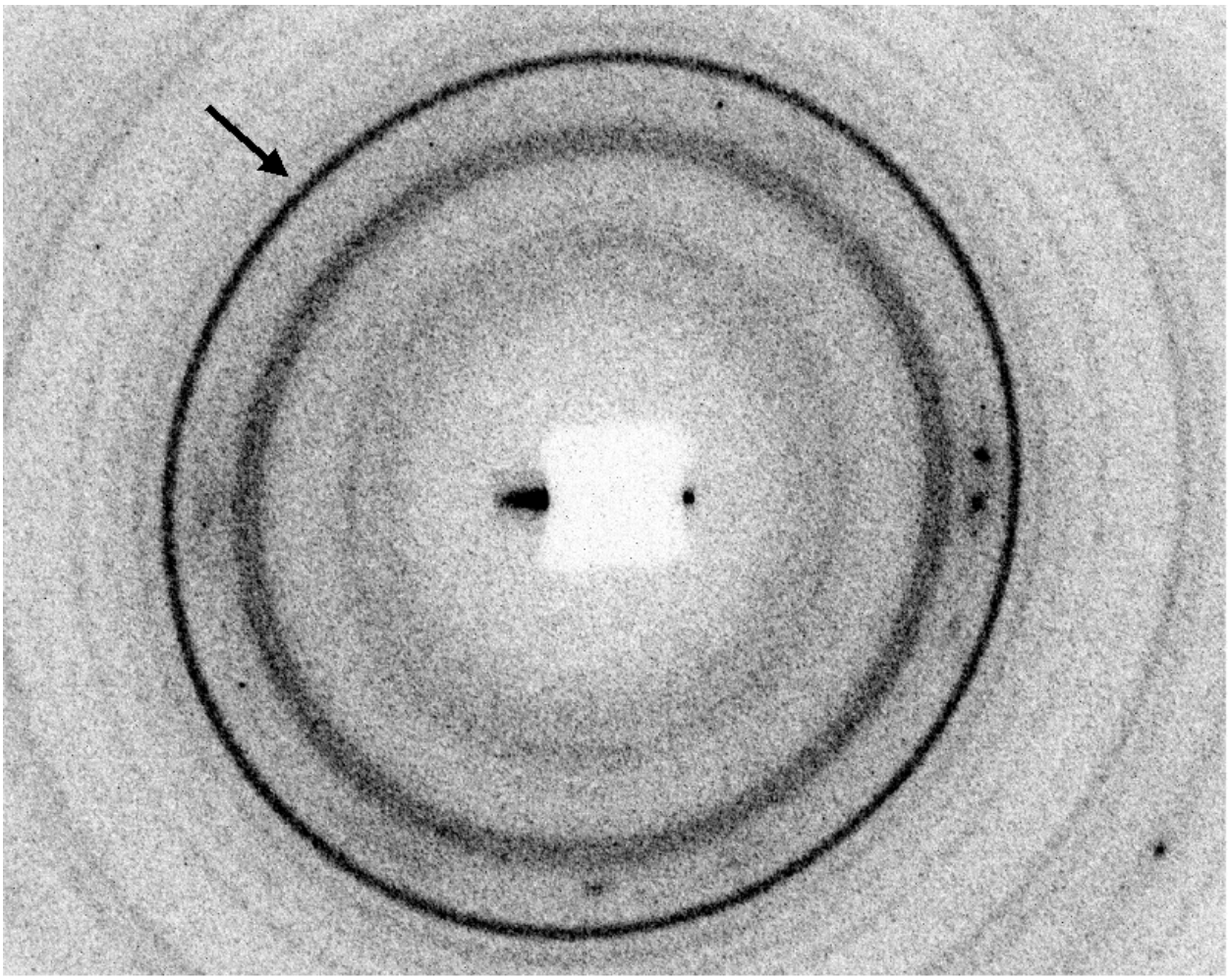

FIG. 1. CCD diffraction image showing appearance of MgB_2 ring (arrow) after reaction of boron fibers with magnesium liquid at 950°C for 2 hours.

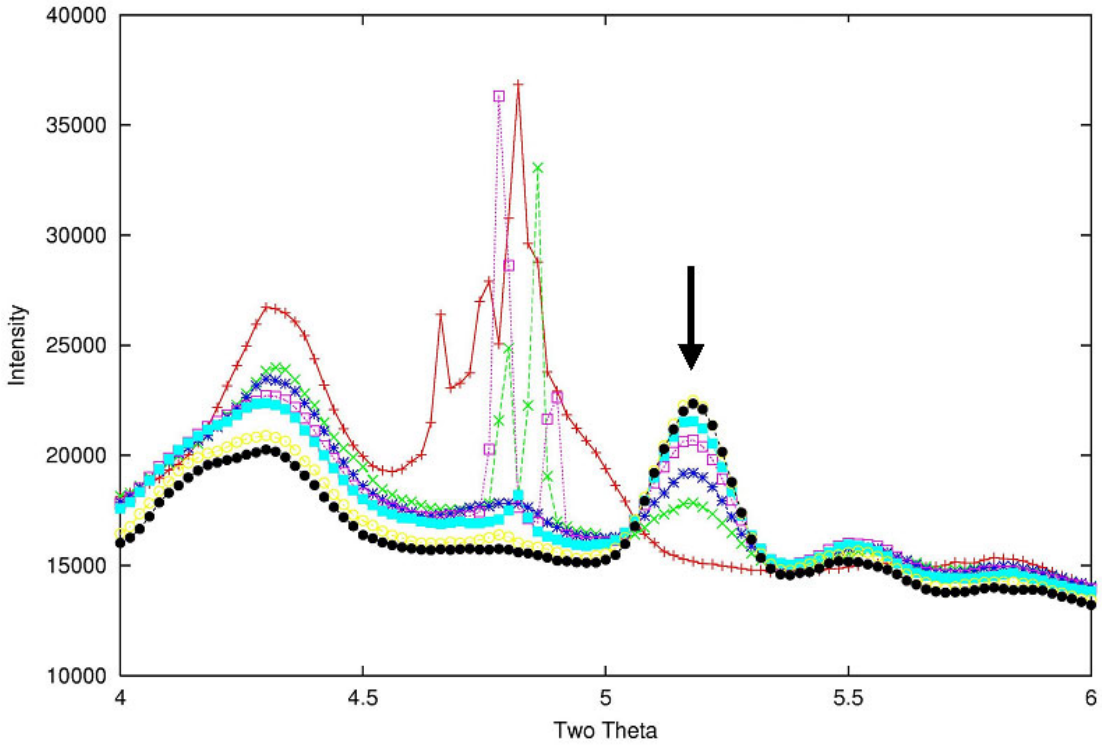

FIG. 2. Intensity versus 2θ plot showing growth of MgB_2 peak (arrow) with time during reaction.