A STUDY ON THE REACTION SEQUENCE DURING THE FORMATION OF NITI FROM ELEMENTAL POWDERS

Dan Cluff and Stephen Corbin
Dalhousie University
Halifax NS B3H 4R2 Canada

Michael Gharghouri
Canadian Neutron Beam Centre, Chalk River Laboratories
Chalk River ON K0J 1J0 Canada

ABSTRACT

Reactive sintering (RS) of elemental Ni and Ti powders to produce the shape memory alloy NiTi has the traditional advantages of a powder metallurgical route. The formation of a dense and homogeneous sintered part is by complex reactions taking place during sintering. One such reaction, known as the thermal explosion mode of self-propagating high temperature synthesis (TE-SHS), is to be avoided if a dense part is desired. The TE-SHS process also influences the homogeneity and volume fraction of NiTi formed in the finished part. The reaction sequence during TE-SHS is not well understood. The present investigation utilizes differential scanning calorimetry (DSC), microscopy and neutron diffraction to study the in-situ reaction sequence. It was found that, at the combustion temperature, a rapid consumption of Ni occurs, and an increase in the fraction of NiTi as well as Ti_2Ni and Ni_3Ti intermetallics results.

INTRODUCTION

NiTi shape memory alloys (SMA) are used in the medical, aerospace and robotic industries due to their corrosion resistance, biocompatibility, good strain recovery and high strength. NiTi is expensive to produce and difficult to machine into finished parts. Powder metallurgy (PM) using elemental Ni and Ti powders could help reduce the costs through the production of near net shape parts and reduced material costs. Since the early 80's investigations into the suitability of PM to produce NiTi have been carried out[1–20]. Some have concentrated on using pre-alloyed powders[5,11,12,17,21]. These show good homogeneity but are expensive[1,11]. Others have utilized less expensive elemental Ti and Ni powders in an attempt to form a homogeneous NiTi during sintering[1,3,4,6–9,13–16,22]. The difficulty in producing a homogeneous dense specimen is partly due to the complex phase formation that occurs during heating as outlined in the binary phase diagram in Figure 1. During the production of NiTi from elemental Ti and elemental Ni, Ti_2Ni and Ni_3Ti are also produced. These two intermediate phases can be difficult to eliminate.

The desirability of residual porosity when sintering depends on the end use. In the sintering of NiTi, self-propagating high temperature synthesis (SHS) is a fact of life that can lead to near net shape but porous