An Experimental Research on Solid-phase Combustion synthesis of NiAl and TiAl Intermetallics

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ABSTRACT

The self-propagating high-temperature synthesis (SHS) of NiAl and TiAl intermetallic compounds was studied. Effects of initial sample density, preheating temperature, and particle size of the reactants on the combustion characteristics, flame-front velocity, combustion temperature and composition of combustion products were investigated. The addition of TiC and TiB2 particles as the reinforcing phase into the NiAl and TiAl compounds, respectively, was studied. Experimental observations indicated that the SHS process of NiAl formation was preceded by the fast propagation of the self-sustained flame front, and the final products were slightly shrunk. The increase of initial sample density and preheating temperature was found to increase the flame-front propagation velocity. The decrease of particle size of the reactants significantly increased the flame velocity about from 20 to 100 mm/s. Due to the dilution effect, the addition of TiC particles in the green compacts lowers the combustion temperature, and thus reduces the flame-front velocity. TiC-added samples experienced a volume expansion during the SHS process and therefore yielded end products with a lower density, in comparison with those obtained from the TiC-free samples. X-ray diffraction (XRD) analysis identifies the formation of a single-phase product of NiAl from the samples without TiC addition. For the samples with TiC addition, the increase of reaction temperature by heating the compact prior to ignition effectively enhances the completeness of phase conversion to form NiAl. Based upon the measured data obtained in this study, the activation energy of 128.64 kJ/mol was deduced for the combustion synthesis of NiAl. In the formation of TiAl, the samples swelled up obviously after combustion, leading to an expansion of volume. The flame-front propagation velocity and combustion temperature was increased by increasing the initial sample density and preheating temperature, and by decreasing the particle size of the reactants. Due to the in-situ formation of TiB2, the samples containing high contents of boron were found to have higher flame-front propagation velocity and combustion temperature. Moreover, volume shrinkage was observed on the TiAl-TiB2 compacts, thus resulting in end products with a higher density in comparison with those without boron addition. Results of XRD analysis indicated that in addition to the TiAl phase, the existence of Ti3Al in the final products of the Ti-Al system was detected.

Keywords : SHS, NiAl, TiC, TiAl, TiB2, flame-front velocity, combustion temperature, composition, XRD, activation energy, particle size, preheating temperature

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