Combined In-Situ Dilatometer and Contact Angle Studies of Interfacial Reaction Kinetics in Brazing

V.R.Davé, D.A. Javernick, D.J. Thoma, M.J. Cola, K.J. Hollis, F.M. Smith, and L. B. Dauelsberg, Los Alamos National Laboratory

Introduction

Multi-component dissimilar material braze joints as shown in Figure 1 consisting of dissimilar base materials, filler materials and wetting agents are of tantamount importance in a wide variety of applications. This work combines dilatometry and contact angle measurements to characterize in-situ the multiple interfacial reaction pathways that occur in such systems. Whereas both of these methods are commonly used tools in metallurgical investigation, their combined use within the context of brazing studies is new and offers considerable additional insight. Applications are discussed to joints made between Beryllium and Monel with TiH_2 as the wetting agent and Cu-28%Ag as the filler material.

Procedure

Wetting trials were conducted in a commercial refractory hot zone vacuum furnace using a digital video imaging system to acquire dynamic contact angle data. Dilatometry was performed on a quench dilatometer using the same thermal profile as is used for the actual braze. Metallurgical analysis consisted of metallographic examination, SEM analysis including backscatter imaging, and electron microprobe analysis.

Results and Discussion

Figure 2 shows a dilatometer trace superimposed on the thermal profile for a typical brazing run which joined Monel to Beryllium using TiH_2 as the wetting aid and Ag-28%Cu (WESGO Cusil) as the filler material. The dilatometer trace clearly shows several distinct event, including binder decomposition, melting, and several distinct sigmoidal reaction curves. Figure 3 shows the corresponding braze microstructure for these brazing conditions. *This is the first such data available for a complex braze of any kind, and clearly indicates the potential of this method for studying in-situ reaction kinetics.*

The sensitivity of the braze microstructure to the amount of TiH_2 was studied in addition to variations in brazing parameters to investigate the formation of various phases. Of particular interest is the kinetics of formation of the Be-Cu delta phase intermetallic as a function of both brazing conditions (times and temperatures) as well as the amount of TiH_2 present at the Be interface. This was characterized through a series of time-temperature cycles: 810C, 830C, 850C, and 950C for temperatures and either 10min. or 30min. for dwell times at temperature. Additionally, wetting studies with Ag-28%Cu on TiH_2 / Be were conducted. These test specimens also doubled as reactive spreading specimens since the reaction rate information can be extracted by knowing the time-temperature history of the samples and metallographically investigating the resultant reaction layer thickness.

Conclusion

Dynamic wetting and dilatometer experiments were used to characterize the in-situ reaction kinetics of a complex, multi-component braze system. This approach emphasizes in-situ observation as opposed to multiple thermal cycles in which parts are examined on quenching. The principal advantage of a completely in-situ method is that kinetic behavior is directly extracted from the in-situ measurements. It is envisioned that this method may be fruitfully applied to variety of brazing issues such as: ceramic to metal brazing, the wetting and reaction behavior of a variety of metallization or plating treatments, and in-situ investigation of braze / base material interactions over complex and non-isothermal thermal profiles.

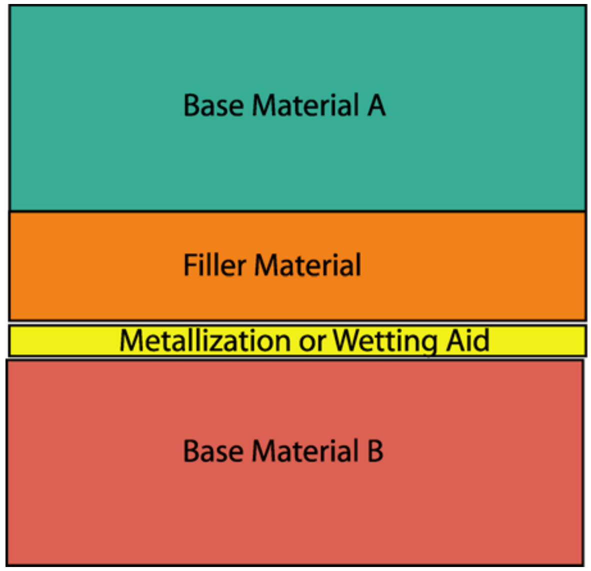

Figure 1.
Multi-component dissimilar material braze joint.

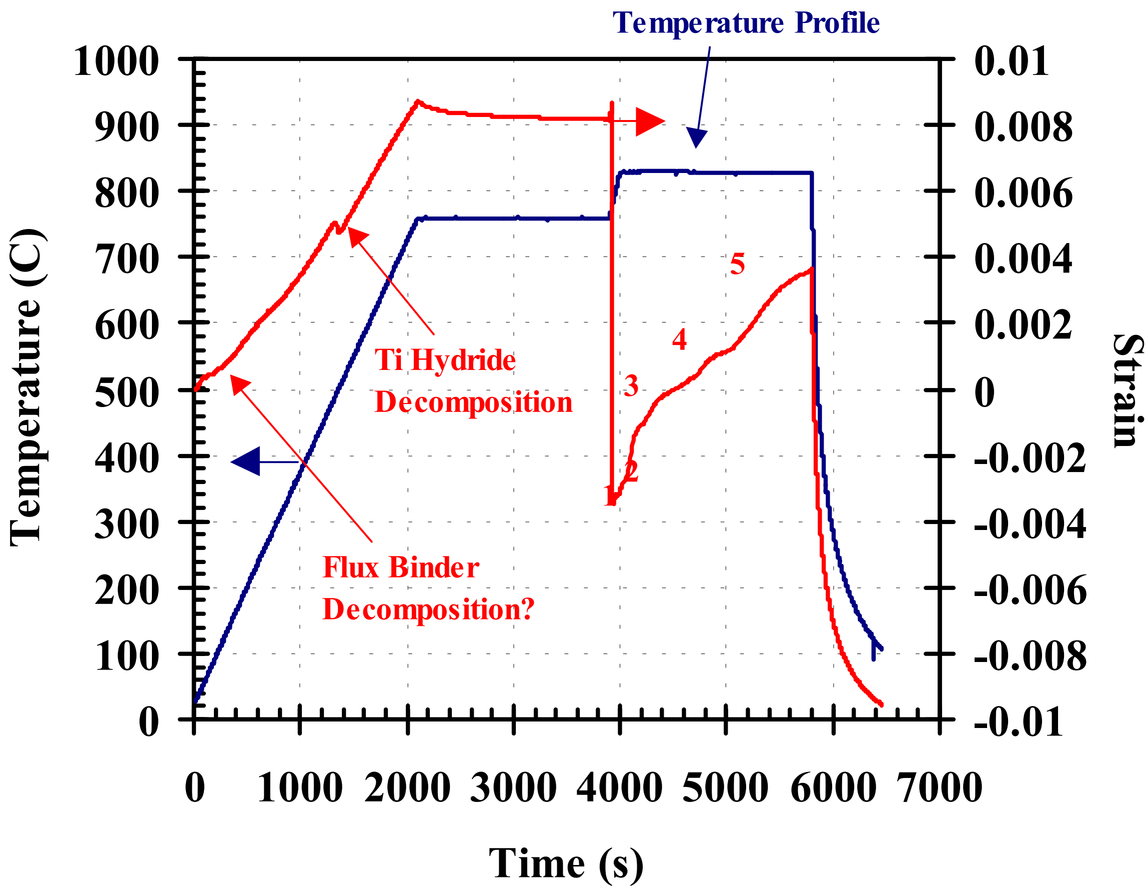

Figure 2.
Dilatometer trace of Be to Monel braze

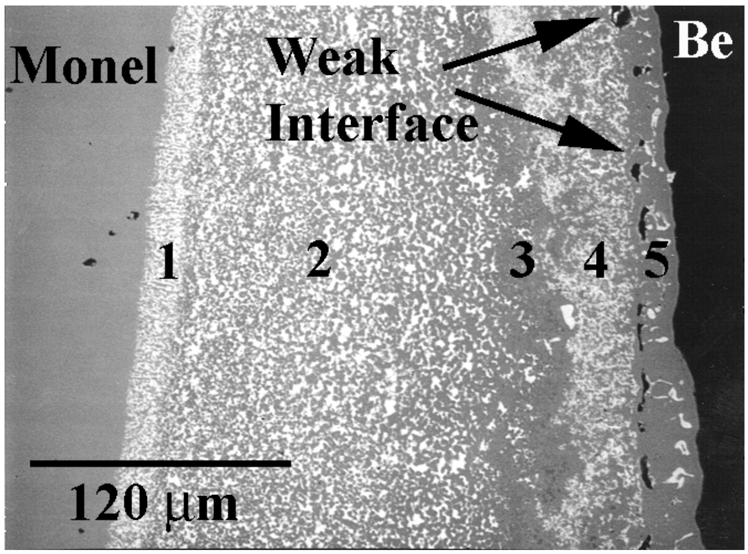

Figure 3.
Microstructure corresponding to Dilatometer Trace in Figure 2.