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Investigating Transport Processes in Multilayer Films

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Metallic thin film multilayers that undergo rapid, self-propagating formation reactions are of interest for several applications including advanced joining technology. The development and optimization of new materials for these applications requires a detailed understanding of mass transport, chemical reactions, heat release and thermal transport processes. With this presentation, we focus on the thermal properties of produced multilayers. Thermoreflectance techniques have been used to characterize the thermal conductivity of different Pt/Al, Co/Al and Ni/Al multilayers. The bilayer thickness dependence of cross-plane thermal conductivity has been determined for various multilayers. The results are examined in terms of conductivity through the reactant layers and the role of interfaces. The interfacial structure and composition of each system has been mapped by cross section transmission electron microscopy. The measured properties are compared with estimates derived from analytical modeling of self-propagating formation reactions. The model developed by Mann et al. (J. Appl. Phys. 1997) to predict how measured flame speeds vary with multilayer design is used to estimate the thermal and mass transport characteristics. This analytical model accounts for reactant layer thicknesses, compositional profiles near interfaces, flame temperatures, measured heats of reaction, measured activation energies, and adiabatic temperatures.

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