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Investigation of the Growth Kinetics of Phases in Ni–Sn System

Authors : Varun A Baheti, Sanjay Kashyap, Kamanio Chattopadhyay, Praveen Kumar, Aloke Paul

Abstract : Ni–Sn system finds applications in the microelectronics industry, especially with respect to flip–chip or direct chip, attach technology. Here the region of interest is under bump metallization (UBM), and solder bump (Sn) interface due to the formation of brittle intermetallic phases there. Understanding the growth of these phases at UBM/Sn interface is important, as in many cases it controls the electro–mechanical properties of the product. Cu and Ni are the commonly used UBM materials. Cu is used for good bonding because of fast reaction with solder and Ni often acts as a diffusion barrier layer due to its inherently slower reaction kinetics with Sn–based solders. Investigation on the growth kinetics of phases in Ni–Sn system is reported in this study. Just for simplicity, Sn being major solder constituent is chosen. Ni–Sn electroplated diffusion couples are prepared by electroplating pure Sn on Ni substrate. Bulk diffusion couples prepared by the conventional method are also studied along with Ni–Sn electroplated diffusion couples. Diffusion couples are annealed for 25–1000 h at 50–215°C to study the phase evolutions and growth kinetics of various phases. The interdiffusion zone was analysed using field emission gun equipped scanning electron microscope (FE–SEM) for imaging. Indexing of selected area diffraction (SAD) patterns obtained from transmission electron microscope (TEM) and composition measurements done in electron probe micro−analyser (FE–EPMA) confirms the presence of various product phases grown across the interdiffusion zone. Time-dependent experiments indicate diffusion controlled growth of the product phase. The estimated activation energy in the temperature range 125–215°C for parabolic growth constants (and hence integrated interdiffusion coefficients) of the Ni_3Sn_4 phase shed light on the growth mechanism of the phase; whether its grain boundary controlled or lattice controlled diffusion. The location of the Kirkendall marker plane indicates that the Ni_3Sn_4 phase grows mainly by diffusion of Sn in the binary Ni–Sn system.

Keywords : diffusion, equilibrium phase, metastable phase, the Ni-Sn system
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