

Contact mechanics and friction processes in ultrasonic wire bonding - Basic theories and experimental investigations

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Abstract

Ultrasonic wire bonding is widely applied in microelectronic packaging. It is a friction welding process consisting of four phases: 1) Pre-deformation and activation of the ultrasonic vibration, 2) Friction between tool, wire and substrate 3) Ultrasonic softening and 4) Interdiffusion. The process is characterized by operating frequencies between 40 kHz and 200 kHz, amplitudes in the order of a few micrometers and contact normal forces between a few cN and a few N, depending on the wire material and size (typically between 20 micrometer and 500 micrometer in diameter). In the present paper we report experimental results on the relative motion between wire, substrate and bonding tool, which are of fundamental importance for modeling of the ultrasonic wire bonding process. We also discuss local temperatures at the wire/substrate interface and the process of oxide removal in the contact zone. This „self-cleaning“ process is the core of a theoretical model for calculating the bond strength as a function of process parameters. Other elements of the theoretical modeling include the softening-effect of the wire material as well as the microwelds formation and breakage rates. Experimental results, obtained by advanced high speed video techniques are used to validate the theoretical modeling.