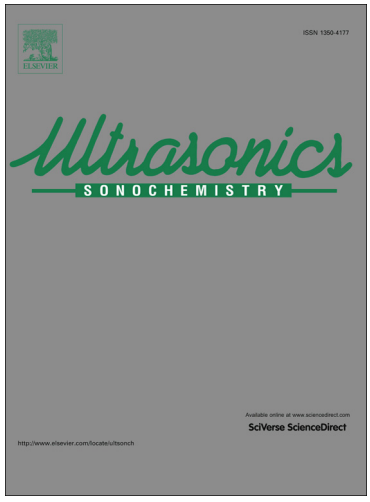

Cavitation at filler metal/substrate interface during ultrasonic-assisted soldering. Part I: Cavitation characteristics

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Cavitation at filler metal/substrate interface during ultrasonic-assisted soldering. Part I: Cavitation characteristics

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Abstract: The cavitation characteristics at filler metal/substrate interface during ultrasonic-assisted soldering were first recorded by high-speed photography in this work. Two kinds of bubbles, steady cavitation bubbles and transient cavitation bubbles were observed. Steady cavitation bubbles did not collapse within one acoustic period and could last longer than 50 acoustic periods. Transient cavitation bubbles formed and collapsed within one acoustic period. The cavitation process was divided into two stages based on the cavitation characteristics. The first violent cavitation stage was in fact the degassing process, which lasted approximately 2700 acoustic periods and was affected by the gas content trapped inside the filler metal and the stronger vibration at the initiation stage of ultrasonic-assisted soldering. The second steady cavitation stage had obvious low bubble density and accounted for the most of the soldering process. Higher cavitation densities were observed when small channel width and large ultrasonic power were used because of larger sound pressures inside the filler metal.

Key words: Cavitation, ultrasonic-assisted soldering, bubbles, bubble density, ultrasonic power, sound pressure

1 Introduction

Ultrasonic-assisted soldering does not require gas shielding or vacuum environment and is considered as an effective, cost-saving, and environment-friendly joining method [1–3]. Since its invention, ultrasonic-assisted soldering has been used to join similar/dissimilar alloys [4,5], metal matrix composites [6,7], ceramics [8], and some difficult-to-join materials [5,9]. So far, studies about ultrasonic-assisted soldering mainly focused on the effects of soldering parameters on the microstructure and mechanical properties of the soldered joints [10–14].

One of the most important stages forming an ultrasonic-assisted soldered joint is the removal of oxide layers at the filler metal/substrate interface [15–17]. Ultrasonic cavitation is fundamentally responsible for the removal of oxide layer [18]. During ultrasonic-assisted soldering, ultrasonic vibrations are introduced into liquid filler metal, and many gas bubbles are formed after the vibration intensity reaches a certain threshold. These bubbles are called cavitation bubbles. The cavitation bubbles undergo repeated nucleation, growth, and eventually collapse violently [18]. The collapse of the cavitation bubbles results in acoustic streaming and micro-jets, producing high instantaneous pressure and temperature