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A contact angle based approach to improve the lead-free solder compatibility on nichrome alloy

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Nichrome (Ni/Cr) alloys are using in many industrial applications due to their high corrosion resistance and thermal stability. It is a known fact that a passivation layer tends to form on these alloy surfaces in ambient conditions. This passivation layer is consisting of chromium oxide. This layer alters the surface energy of the nichrome surface, thereby decreases the wettability and work of adhesion on the nichrome surface. Surface free energy is the work required to increase the surface area of a solid phase. Wettability measurements can be done by calculating the contact angles of sessile droplets formed on nichrome surface. The contact angle θ is related to wettability through Young's Equation. The contact angle of a sessile droplet on a solid surface is measured through the liquid, where a liquid-vapor interface meets the solid surface.

Geometrical basis of young's equation is showed below,

$$\gamma_s = \gamma_{sl} + \gamma_l \, Cos\theta$$

Whereas the contact angle θ relates with surface free energy of the fluids (γ_l), Solid phase free energy (γ_s) and solid-liquid interface energy (γ_{sl}). Work of adhesion (W_a) can be represented by, $W_a = \gamma_s + \gamma_l - \gamma_{sl}$

From young's equation, $W_a = \gamma_l [Cos\theta + 1]$

Lower wettability affects the quality of soldering and thereby the performance of electrical and electronic components. Because poor wettability on the nichrome surfaces leads to poor solderability. Poor soldering can cause a various problem in connecting wires such as resistance variations with time. In this study, a liquid salt solution was used in an acidic environment ($ZnCl_2/HCl$) to remove the oxide passivation layer and, to enhance the wettability of solder on the nichrome surface. Lead-free industrial solder alloy, *SN100C* (*Sn / Cu 0.70% / Ni 0.06% / Ge 0.005%*.) was used as the soldering material. Shapes of the solder drop formed on the pre-treated and non-treated Nichrome surface at 325-350 °C were analyzed by image processing. An image processing software was developed to process the images of the solder droplets and to find the contact angles on the nichrome surface. Polynomial and ellipse fittings were applied to analyze the drop shape. Validation of the algorithm implemented in the software was done by conducting a comparison test with known contact angles of droplets. The validation process showed mean absolute error lower than 1%, confirming that the method of image analysis of a sessile droplet is accurate. Results of the study show that the contact angles of solder droplets were reduced by more than 50 % after the treatment.

Keywords: Nichrome, Wettability, Contact Angle, Solderability