Vapor Pressure Prediction for Stacked-Chip Packages in Reflow by Convection-Diffusion Model

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$$\frac{}{R_w T} \quad (1 \quad) \frac{B}{p_w} \quad \frac{p}{t} \quad \frac{k}{R_w T} \frac{dp}{dx} \quad p \frac{dp}{dx} \qquad (14)$$
$$\frac{}{R_w T^2} \quad \frac{(1 \quad)}{p_w^2} \frac{dp_w}{dT} \quad T \; p$$

Validation data of the SS model is from the work by [11] and these results are what are used to validate the CD Model. In table 1 the parameters are shown for the validation and case studies.

Table 1. Material Properties for Validation Cases.

The material is *1* mm in length and has Dirichlet boundary conditions at both ends, which can be seen in Figure 1. The Initial vapor pressure is based on steam tables, with a function approximating the steam table values and can be seen in equation (5). The heating profile is a ramp profile, which can be seen in Figure 2.

Figure 1. Geometric Layout and Boundary Conditions for Convection-Only CD Model Verification.

Using the profile in Figure 2 and the corresponding properties, the validation of the SS model in the form of the CD Model is verified. The results of the CD Model verification can be seen in figure 3. The validation is complete for the CD Model; there are some very small differences, but that is due to the solver that they used--they used ODE23s, and this paper uses ODE15s, which computes the time step completely differently. Thus with such small differences the code is verified [11].

This is shown in the concentration contours in Figure 12, when the concentration is observed at 250 seconds and the difference is an offset and not drastically different. It even shows that the SS model over

The CD Model should approach the diffusion model when the permeability goes to zero. To illustrate this, a sensitivity analysis is done. As can be seen in Figure 18, as the permeability decreases, the pressure sharply increases, for both reflow profile 1 and for reflow Profile-2.

Figure 17. Concentration at Adhesive Silicon Interface vs Time^2 Sensitivity of CD Model to permeability *k*.

It can be seen that the lower the gas permeability goes the higher the pressure goes. This is to be expected and will continue to increase until it reaches the final diffusion-only term. However, there is an increase in the time taken to reach the final pressure, so the whole process will take longer, and eventually will not be distinguishable from the diffusion terms. Also the concentration when plotted versus time the effect of reducing permeability can be easily seen. As in Figure 17, the concentration rates drop as the permeability gets smaller.

Figure 18. Pressure sensitivity of CD Model with *k*, at Adhesive Silicon Interface.

The reflow 2 profile, difference can be described in the heating rate is different so the pressure follows another saturated vapor curve than reflow 1. The effects of permeability are not completely clear because there is a large dependence on the temperature profile rather than just material properties. Because of this, the results of the sensitivity analysis only show that a decrease in permeability will drive the concentration to the diffusion-only values. This does not, by itself, describe the sensitivity of the rate of moisture loss, thus the temperature reflow profiles and the saturated vapor pressures must be considered as well.

5. Conclusions

In conclusion it is seen that the overall description of the CD Model predicts much lower pressures in the material which is highly dependent on the material property: vapor permeability *k*

soldering reflow with moisture preconditioning , IEEE Transactions on Components and Packaging Technologies 31(2), 252-259, 2008.
5. Shi, X.Q., Fan, X.