

# Reliability of Cu Wire Packages and Molding Compounds

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## 1 Summary

Cu wire has poorer humidity reliability than Au wire. However, sufficient information regarding failure mechanisms and negative factors was not available. We explored the factors of humidity reliability failure for Cu wire packages. As a result, extracted chlorine ions from molding compounds were found to be a major factor, while the pH of extracted water was found to be a minor factor through a Bias-HAST and chemical model simulation. Pd-coated Cu wire improved humidity reliability performance. Cracks and corrosion were the root causes for open failure at positive electrode pads. A simulation suggested the formation of Cu-rich inter metallic compound (IMC) and Cu-poor IMC and the Cu-rich IMC was estimated to be corroded by chlorine ions.

## 2 Features of Technology

- We elucidated the effects of chlorine ions extracted from molding compound and pH of extracted water on humidity reliability. Based on our findings, we developed molding compound well-suited for copper wires.
- We determined the effects of factors external to the molding compound, e.g. the type of wire on humidity reliability.
- We inferred the mechanism of corrosion of Cu/Al IMC by chlorine ions from chemical model simulations.

## 3 History of Development

In recent years, switching from gold wires to copper wires is accelerating due to the significant rise in the price of gold. Because copper wires have better electric and heat conductivity than gold wires, thick copper wires have been used for conventional power circuits including discrete transistors. However, as copper wires take the place of gold wires due to the rising price of gold, the focus has been shifted to lowering costs, and fine copper wires below 1 mil are being produced for use in IC packages, including BGA.

Though many studies on the reliability of Cu wires under high temperature storage have been reported, most of them are on the reliability before encapsulation process. Also, there have been few reports on humidity reliability (Bias HAST, uHAST [= no bias], PCT). In spite of copper has lower stability compared to gold, there is less knowledge about the reliability of copper wires. This has been a barrier to the application of copper wires. We have identified factors affecting copper wire's humidity reliability. We have also surmised mechanisms that degrade humidity reliability by assimilating the results of chemical model simulations.

## 4 Content of Technology

### (1) Bias HAST Evaluation

**Figure 1** shows the results of Bias HAST for different molding compounds. Low chlorine ion concentration and high pH were effective for improving humidity reliability. Also, by using palladium-coated copper wires, halogen free compound B passed 336 hours though defects occurred with compound B using bare copper wires.

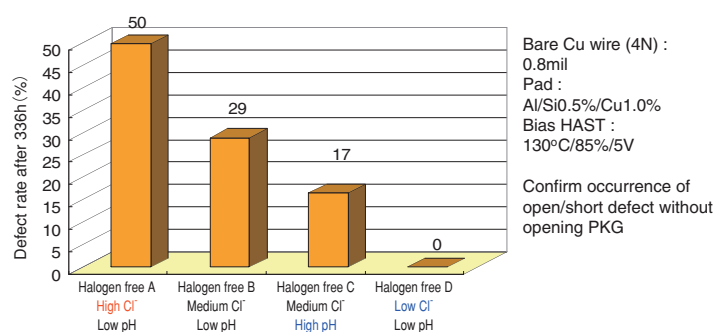


Figure 1 Effect of molding compound type on humidity reliability

## (2) Chemical Model Simulation

As shown in **Figure 2**, the formation of  $\text{Cu}_3\text{Al}_2$  (Cu-rich IMC) and  $\text{CuAl}$  (Cu-poor IMC), are expected to form during bonding by chemical model simulation. Depending on the type of IMC, reactivity with chlorine ions differs.

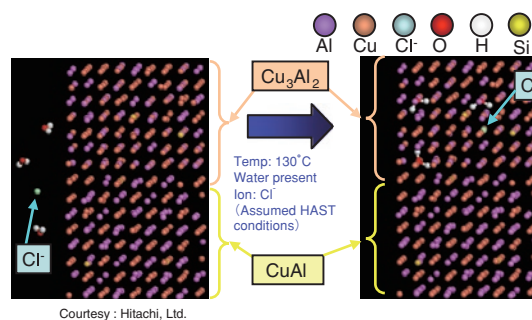


Figure 2 Reaction schematic between Cu/Al IMCs and chlorine ion

To evaluate reactivity of different IMCs and chlorine ion, we calculated the desorption energy of chlorine ions for different IMCs. As shown in **Figure 3**, Cu-rich IMC is expected to be corroded by chlorine ions.

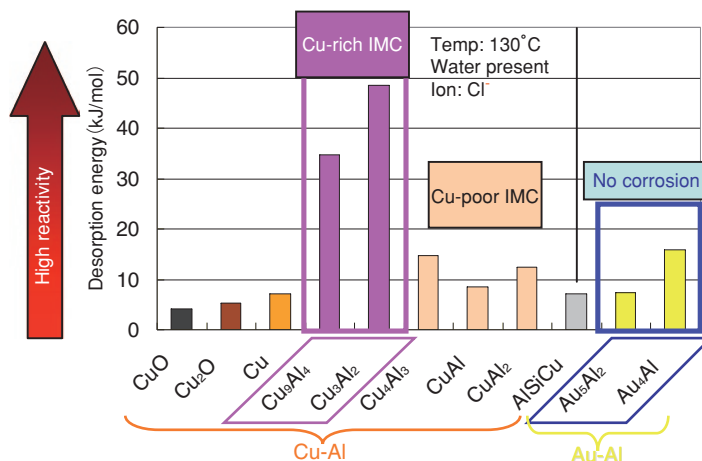


Figure 3 Reactivity between each IMC and chlorine ions under HAST condition

## 5 Future Developments

- Further development of molding compounds with outstanding humidity reliability.
- Elucidation of the mechanism of faulty occurrences in humidity reliability of Pd coated copper wires.

### [References]

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- 2) Tomohiro Uno, et al., Surface-Enhanced Copper Bonding Wire for LSI, ECTC2009