Industry Newsletter &
Technical Publication

GAISER TOOL COMPANY

• Inventors of the Ceramic Capillary •

Volume III
Issue 2
March 2005

Copper Wire Bonding

A Low Cost Solution to Gold Wire Bonding?
Part 1: The Free Air Ball Formation

Introduction

Copper wire as a replacement to the ever popular Gold wire bonding is nothing new to the semiconductor industry, in fact the history of copper as a replacement to the more expensive gold material started about 25 years ago (early 1980's). Since then the interest in copper surges every time the price of gold rises. The reason is low cost and better electrical and thermal characteristics.

Electrical designers as well as financial planners see in copper the ideal solution for cost and performance but fail to see its overall implementation and maintenance issues that sometimes outweigh the intended savings test.

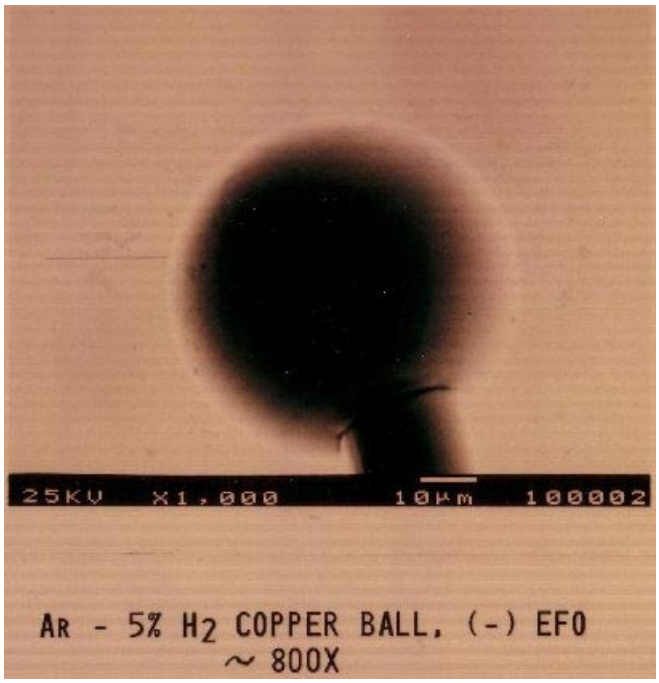
Part 1

The early 1980's brought several major semiconductor assembly houses to evaluate Copper (Cu) as a cost reduction alternative and a performance improvement for the emerging higher performance semiconductor devices. Semiconductor houses such as Texas Instruments, Inc., Motorola and Hitachi launched in the early 1980's intensive development programs to understand and implement Cu wire as a substitute to the more expensive Gold (Au) wire. Their lessons helped to understand many of the subtleties and facts about working with copper wire.

The most important fact about dealing with Cu is the need for a protective atmosphere to minimize oxidation of the entire wire surface and especially of that of the free air ball. The obvious choice as a protective atmosphere gas was N2, abundant, cheap and safe to use but unfortunately the control of ball formation (size and shape) does not depend solely on the protective gas but on the source of energy responsible for melting the Cu wire. This system is known as the EFO and it stands for Electronic Flame off Mechanism.

The control of ball size and shape depends on the ionization gap breakdown voltage, the amount of current flow and the duration of the current flow or spark time.

Experimental results indicated that Nitrogen alone is not capable of providing consistent shape even though the balls formed were free of Oxygen. So, Hydrogen was added in small quantities to help control ball shape. The results of such experiments indicated that percentages in the range of 5% were enough to provide good and consistent ball shape control.



EFO types (positive or negative) were also evaluated by Mitsubishi Wire Company in Japan to better understand its impact in ball shape consistency and concentricity. Their experimental results favored strongly the Positive type EFO as a better method to form consistently shaped free air copper balls.

The focus of Copper wire ball formation shifted to size control as alternative to bond semiconductor devices with smaller pad openings. The experiments here focused on different gas chemistries that could allow an easier and smaller current flow between the EFO electrode (e-torch) and the Cu wire. Various formulations were eventually developed to help reduce breakdown voltage and current flow which allowed for a much higher EFO control resolution.

Coming Next: Part II Copper Ball Bonding, Facts and Issues