Direct Bonding of Copper with Aluminium Oxide

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Abstract- DBC substrate was tried to be prepared using a copper sample having a slot on one of its edge and alumina crucible. Both the materials were kept in a Muffle Furnace and are heated up to temperature range of 1025 C for about 7-8 hours under normal atmospheric conditions of the furnace. A very delicate bond was observed between the copper sample and alumina crucible when observed with the naked eye. Before taking the trial for bonding. the copper samples were cleaned using 10 % HCl solution and are pre oxidized in a muffle furnace at 350 C. SEM Analysis was conducted with pre oxidized copper samples to observe the thickness of the oxide layer and its texture on different copper samples oxidized for different time periods. The result was analyzed to infer the optimum thickness of oxide layer required for the formation of good bond.

Key words : DBC , alumina, copper, SEM, EDS, oxide layer , pre-oxidation

1.INTRODUCTION

DBC substrate have been widely used in power electronics and aviation industry as a heat sinking device. It is generally used under extreme temperature drops, for example in airplanes the temperature varies from -40 C to 140 C. In such circumstances it becomes important to check the thermal reliability of the DBC substrate.[1] Thermal Reliability depends on the strength of the substrate and its ability to not get failed, i.e., the materials of which the DBC substrate is made up should not get peeled off from each other under the applied load.[2] The peeling strength of the DBC substrate is a very important criteria which describes its efficiency and reliability.[3]

That is why the analysis of oxide layer formation on the surface of copper is a very aspect while preparing a direct bond using copper and ceramic. The thickness of oxide layer decides the efficacy of the direct bond formed. The thickness of the oxide layer should be optimum and enough for the formation of direct bond.[4] We need to take care of the fact that oxygen is required for the formation of bond but in a very limited quantity, else it would result in formation of copper oxides precipitates which would ultimately result in weakening of the direct bond.[5]

2.EXPERIMENTAL PROCEDURE

2.1 CLEANING OF COPPER SAMPLES

A copper sheet was arranged with about 95 % purity and is cut into small pieces of 3*3 cm and 0.89 mm thickness.

Each sample was cleaned with 10 % HCl solution for 3-5minutes and then washed with De-ionized water.

Fig – 1 : Copper samples after cleaning

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2.2 PRE-OXIDATION OF COPPER SAMPLES

After the samples were cleaned they are taken for pre – oxidation. The Pre oxidation was done in a Muffle Furnace at 350 C for different time periods starting from 120 minutes up to 240 minutes.

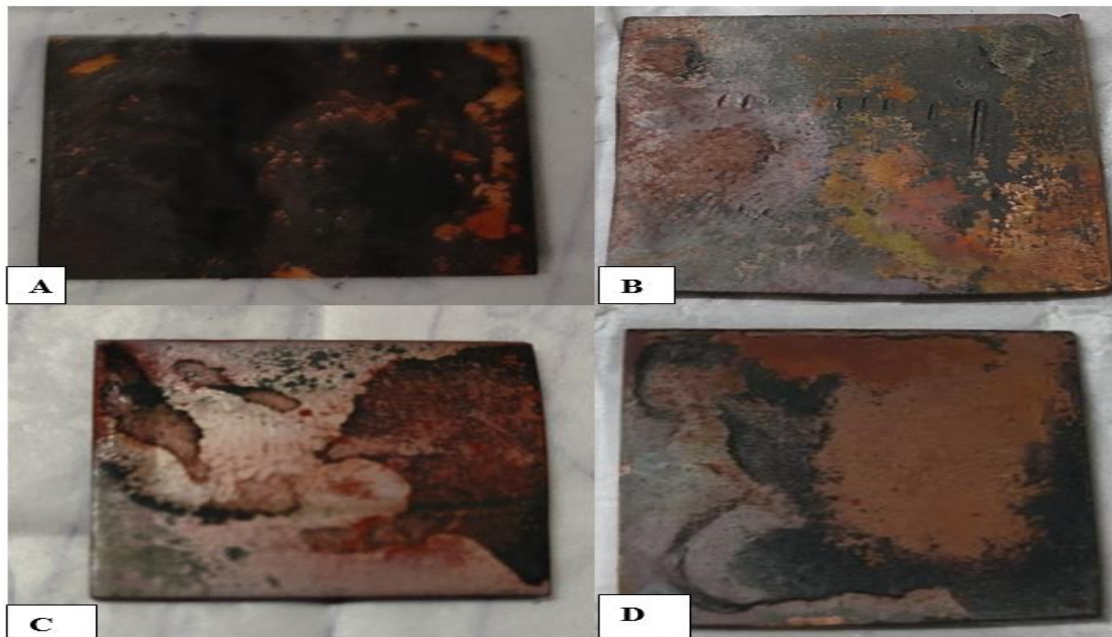


Fig -2 : Copper samples pre oxidized at 350 °C for [A] 240 min [B] 200 min [C] 150 min [D] 120 min

2.3 DIRECT BONDING TRIAL UNDER NORMAL ENVIRONMENTAL CONDITIONS

After pre oxidation is completed SEM analysis of copper samples were performed and the observations are recorded.

The ceramic material chosen for direct bonding with copper is Aluminum oxide crucible.

Sample with optimum amount of oxide layer formed on its surface which have not been peeled off and is enough for direct bonding is chosen.

Copper sample with a slot on one of its edge is placed on one edge of the alumina crucible and they are put inside a Muffle Furnace.

Fig -3 : Copper and Alumina crucible taken out of the muffle furnace

The temperature of the furnace is set to 1075 C and the samples are put inside them. The environment of the furnace is normal atmospheric condition although controlled atmospheric condition is required for formation of direct bond.

The samples are heated up to 1025 C for about 8 - 9 hours and are taken out of the furnace afterwards.

It was observed through naked eye a small bond formation have taken place between copper and alumina crucible.

3. RESULT & DISCUSSIONS [SEM & EDS ANALYSIS]

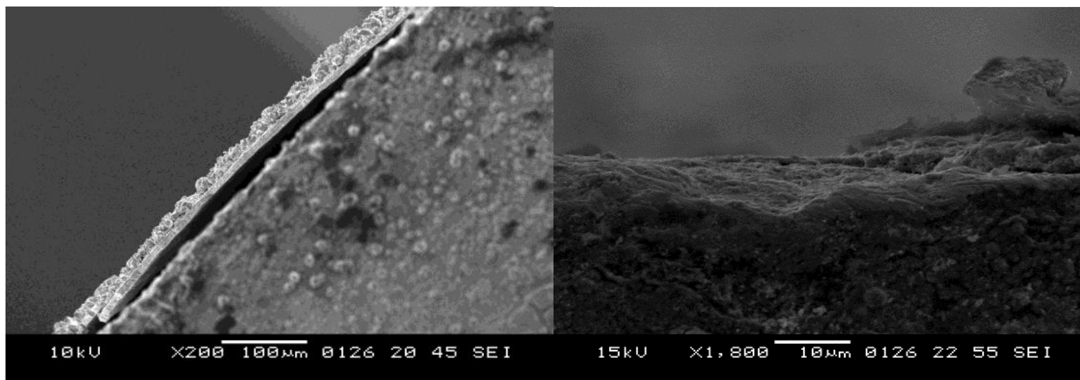
3.1 PRE-OXIDIZED COPPER SAMPLES

SEM Analysis of Pre oxidized copper samples were carried out. It was observed that a thick and clear oxide layer was formed on the copper surface which are pre oxidized for longer time duration as compared to those with lesser time duration.

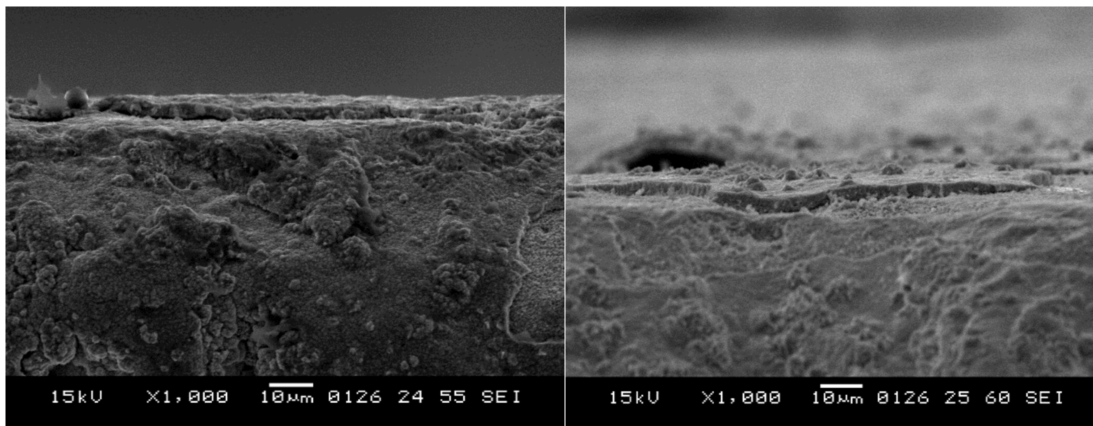
Approximate thickness of oxide layer was determined using ImageJ software.

SEM analysis of surface and cross section of the copper samples were taken to get the best possible result of oxide layer formation on the surface of copper.

EDS analysis also shows that the elements present were Cu and O at the surface analyzed.

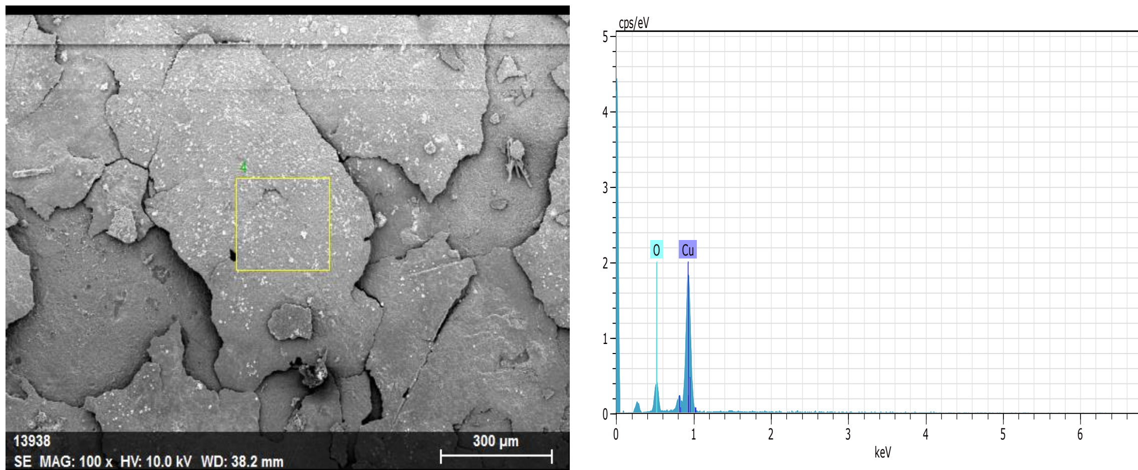


5.9 micron [240mins] **3.1 micron[200 mins]**



2.8 micron [150 mins] **2.7 micron[120 mins]**

Fig-4: SEM Micrographs of oxidized copper samples for different time periods



El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
Cu	29	L-series	87.89	87.89	64.64	14.08
O	8	K-series	12.11	12.11	35.36	3.08
		Total:	100.00	100.00	100.00	

Fig -5 : EDS Analysis of oxidized copper sample oxidized at 350 C for 200 min

3.2 DE-BONDED OXIDIZED COPPER SAMPLE WITH ALUMINA CRUCIBLE

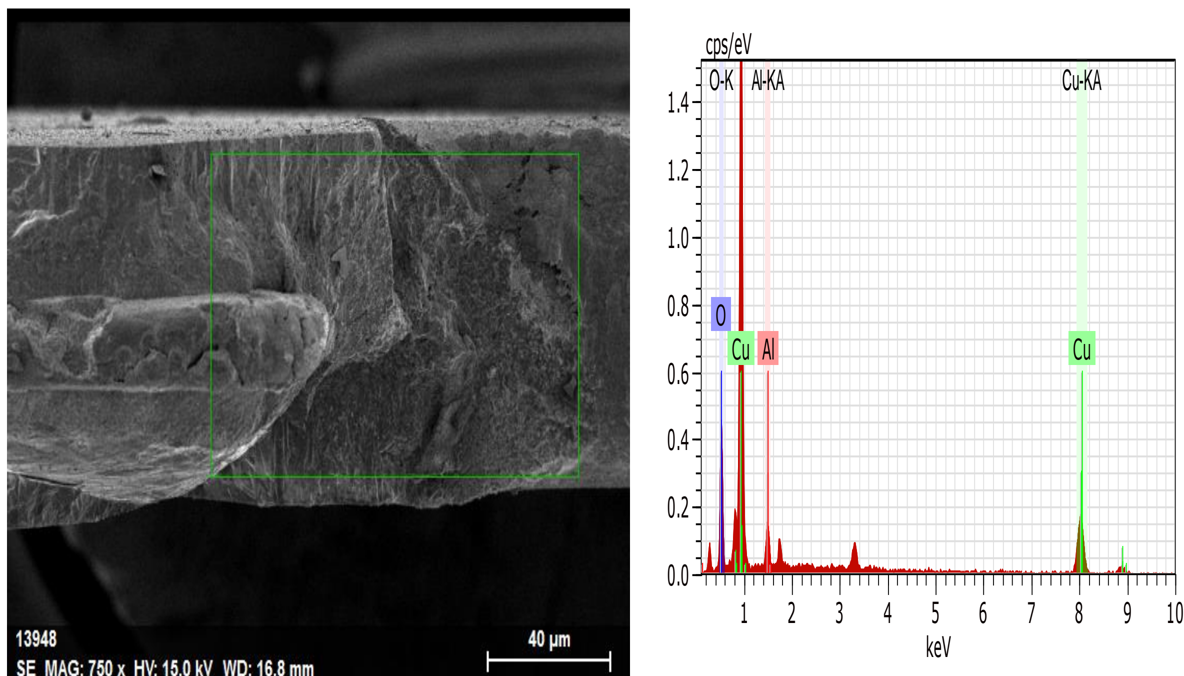
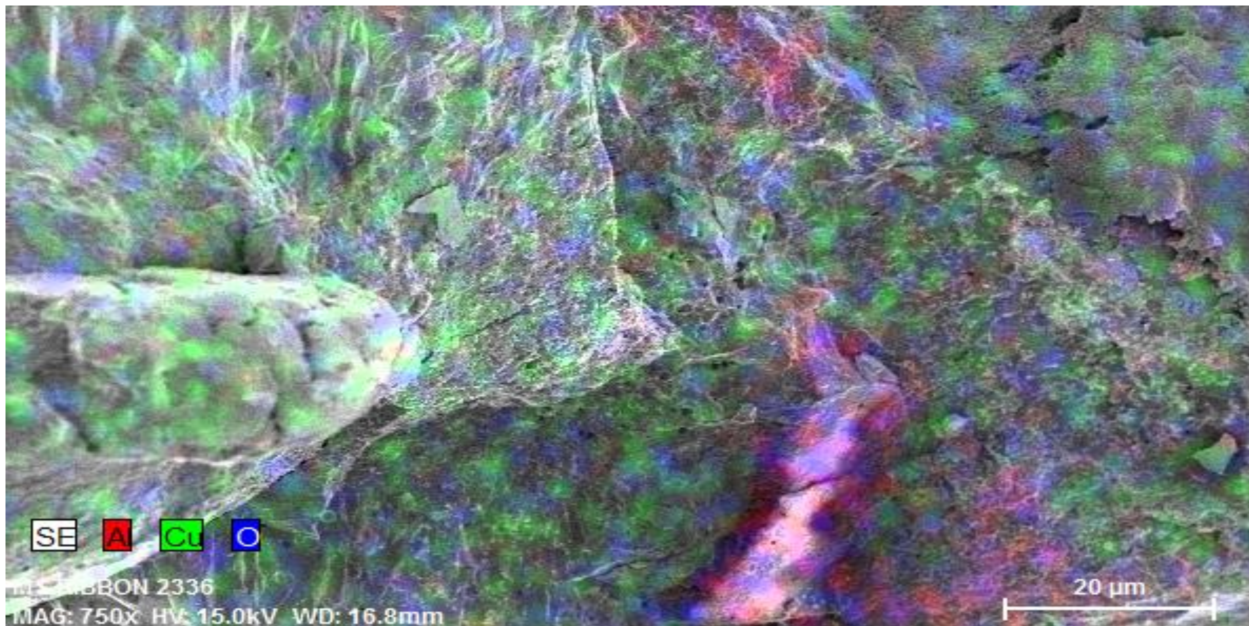
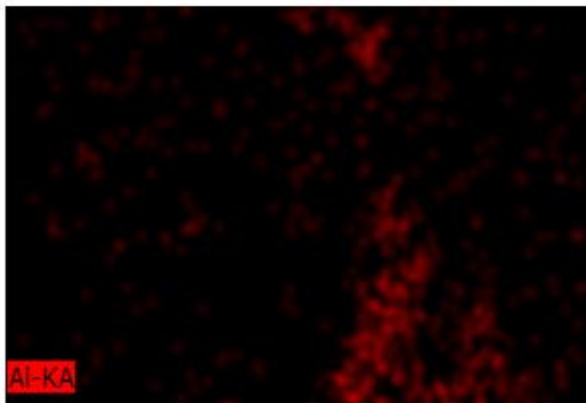
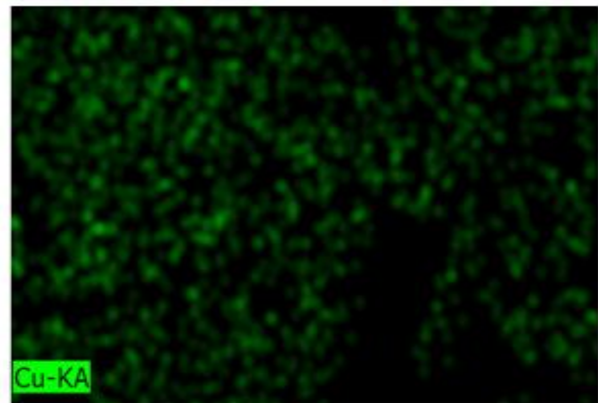
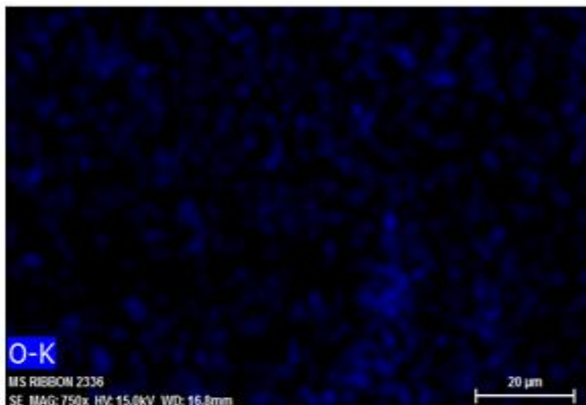


Fig-6 : EDS Analysis of de-bonded pre oxidized copper sample with alumina crucible









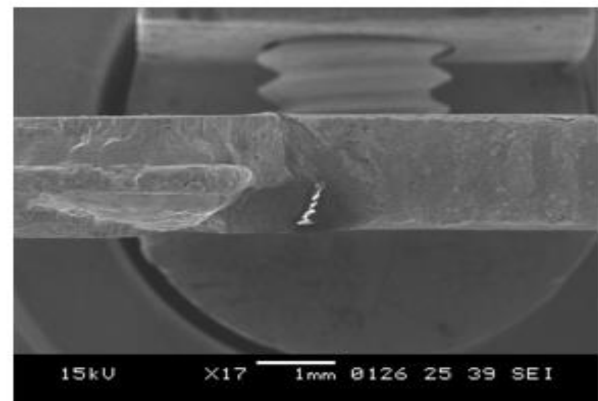


Fig- 7: EDS Mapping Report of de-bonded copper sample pre oxidized for 120 mins wit alumina

From EDS report it can be inferred that the Cu, Al and O , these three elements are present on the surface of the copper sample which is used for bonding trial with alumina crucible. So we might claim that some kind of reaction might have taken place between copper oxide layer present on the copper surface and alumina crucible inside muffle furnace when kept for 7-8 hours.

4.CONCLUSION

From our experiment conducted and analysis done based on SEM micrographs and EDS Report we can conclude the following points:

- On oxidizing the copper samples at 350 C for 120 to 240 mins , a layer of oxide containing Cu and O atoms is formed on its surface. This layer is visible under SEM and presence of Cu and O elements were revealed under EDS Report.
- On keeping the oxidized copper sample in direct contact with alumina crucible inside a muffle furnace at 1025 C for 7-8 hours, the presence of Al was revealed from EDS Report and EDS Mapping.

5.REFERENCES

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