

Brazing Remedy for Solidification Cracking During Copper to Aluminum Welding

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Abstract:

Fusion welding for dissimilar joints such as aluminum to copper is very difficult because of the crack initiation at the fusion line, then progress to joint failure. By this work, the brazing by filler metal (Brass, 60% Cu and 40% Zn) which have a melting temperature more than aluminum melting temperature, so that brazing will contain some fusion at the aluminum side, this will help in the process of crack remedy. The bonding mechanism shows welded cracks by brazing capillary, and the structure near the brazing line is dendritic structure. While the cracking at the fusion process for the same bond shows cracks with casting structure.

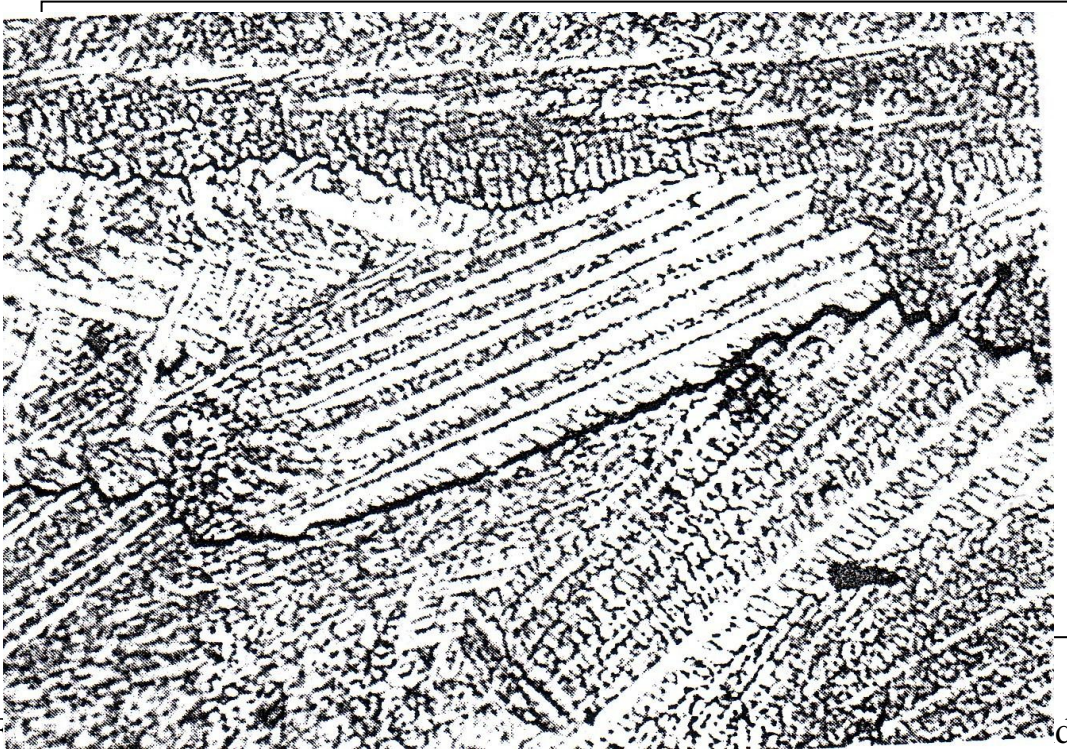
الملخص:

اللحام الأنصهاري لوصلات اللحام الغير المتماثلة مثل الألمنيوم مع النحاس تعتبر من وصلات اللحام الصعبة وذلك لتكون التشققات على خط الانصهار، و التي تؤدي الى فشل تلك الوصلات. هذا العمل قدم لنا وصلت لحام نوع المونة لنفس الوصلة السابقة باستخدام المونة نوع البراص (٦٠ % نحاس و ٤٠ % زنك) والتي تمتلك درجة انصهار أعلى من درجة انصهار الألمنيوم مما توفر لنا إمكانية صهر الألمنيوم ولو بشكل قليل للسماح إلى المونة بالتخلل داخل تلك الشقوق ومعالجتها. إليه الربط تبين لنا أن الشقوق تم معالجتها بفعالية المونة عن طريق الخاصية الشعرية مع وجود البنية الشجرية. بينما البنية في حالة اللحام الانصهاري تكون مشابه لبنية السباكة مع وجود التشققات.

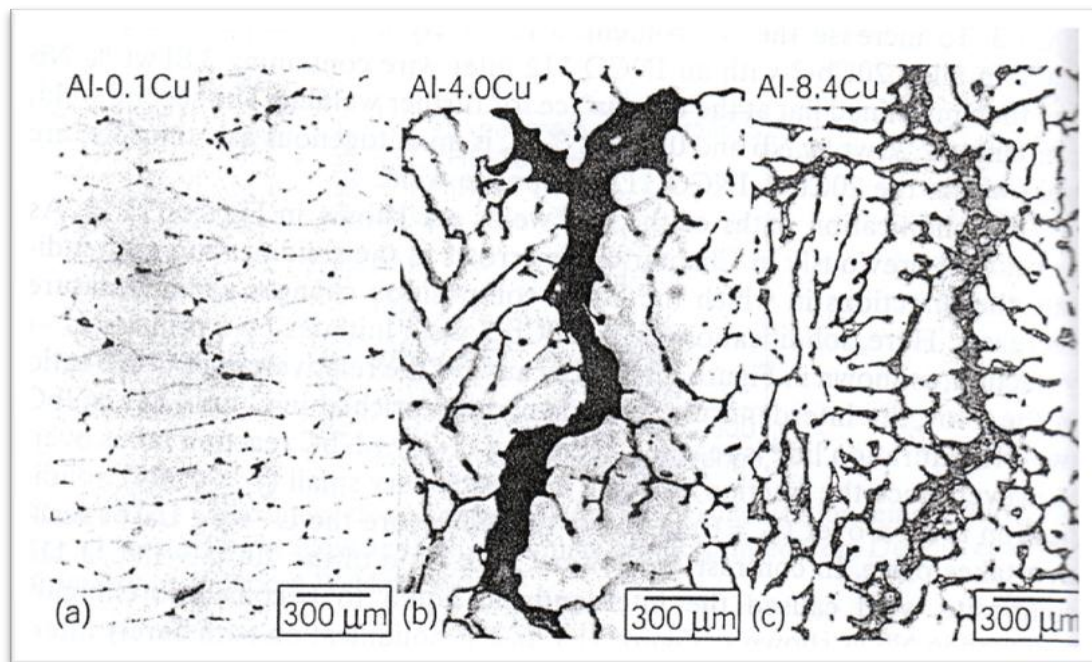
Introduction:

Solidification cracking, which is observed frequently in casting and ingots, can also occur in fusion or welding, as shown in Figure (1). Such cracking is intergranular, that is, along the grain boundaries of the weld metal[1]. It occurs during the thermal stage of solidification, when the tensile stresses developed across the adjacent grains exceed the strength of the almost completely solidified weld metal [2-4]. The solidifying weld metal tends to contract because of both solidification shrinkage and thermal contraction. The surrounding base metal also tends to contract, but not as much, because it is neither melted nor heated as much on the average. Therefore, the contraction of the solidifying metal can be hindered by the base metal, especially if the workpiece is constrained and cannot contract freely. Consequently, tensile stresses develop in the solidifying weld metal. The severity of such tensile stresses increases with both the degree of constraint and the thickness of the workpiece. The various theories of solidification cracking [4-7] are effectively identical and embody the concept of the formation of a coherent interlocking solid network that is separated by

essentially continuous thin liquid films and thus ruptured by the tensile stress[2]. Figure (2a) shows an aluminum weld with little Cu (alloy 1100 gas-metal arc welded with filler 1100), and there is no evidence of cracking. Figure (2b) shows a crack in an aluminum weld with about 4% Cu (alloy 2219-gas-metal arc welded with filler 1100). Figure (2c) shows a crack healed by the eutectic liquid in an aluminum weld with about 8% Cu (alloy 2219 gas-metal arc welded with filler 2319 plus extra Cu) [8]. In our work we are observing the crack remedying by the work of brazing filler metal alloy just after solidification by the action of capillary action, which means that cracks can be welded by this process.



of 7075 aluminum (magnification 140X).[1]



Figure(2): Aluminum welds with three different levels of Cu. (a) almost no Cu; (b) 4% Cu; (c) 8% Cu, [2].

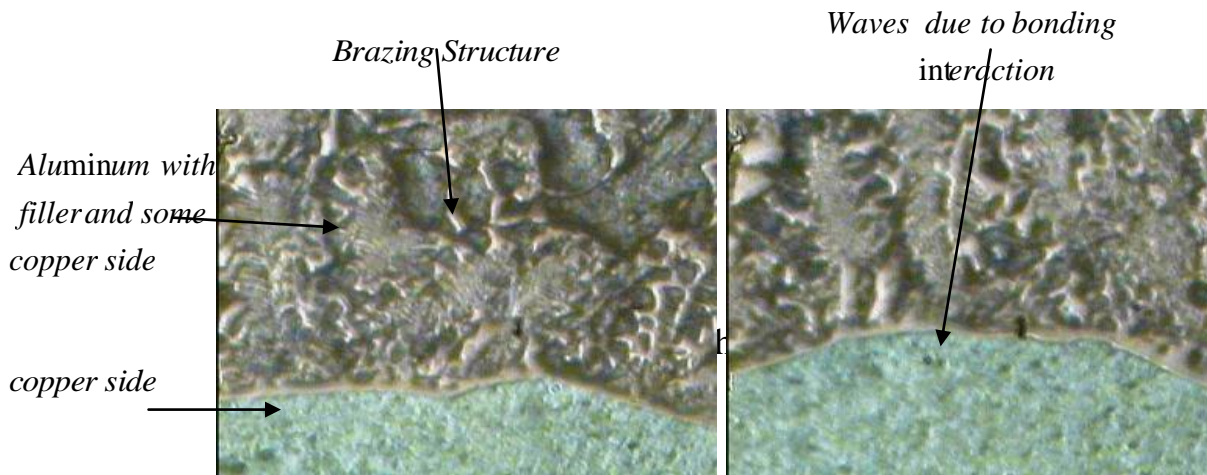
Experimental Work:

An oxyacetylene brazing of aluminum to Copper joining process was carried out by using brass filler metal alloy (60% Cu and 40% Zn). To evaluate the bonding zone of dissimilar welding process, cleaning of joint sides by alcohol, and polishing the sides that which will be welded were performed. In this process the welding is brazing type, but with a little of fusion in aluminum side, because of that filler metal alloy melting at more than aluminum melting temperature, so this process had some fusion at the brazing zone. By cutting the bonding zone in the cross-sectional direction. Microstructural testing should be taken to explain bonding mechanisms. Oxyful fusion welding also was carried out for the same joint, for comparing with the above bond. Grinding and polishing were used to preparing samples for microstructural testing. Etching solution is FeCl_3 to reveal the grain boundaries.

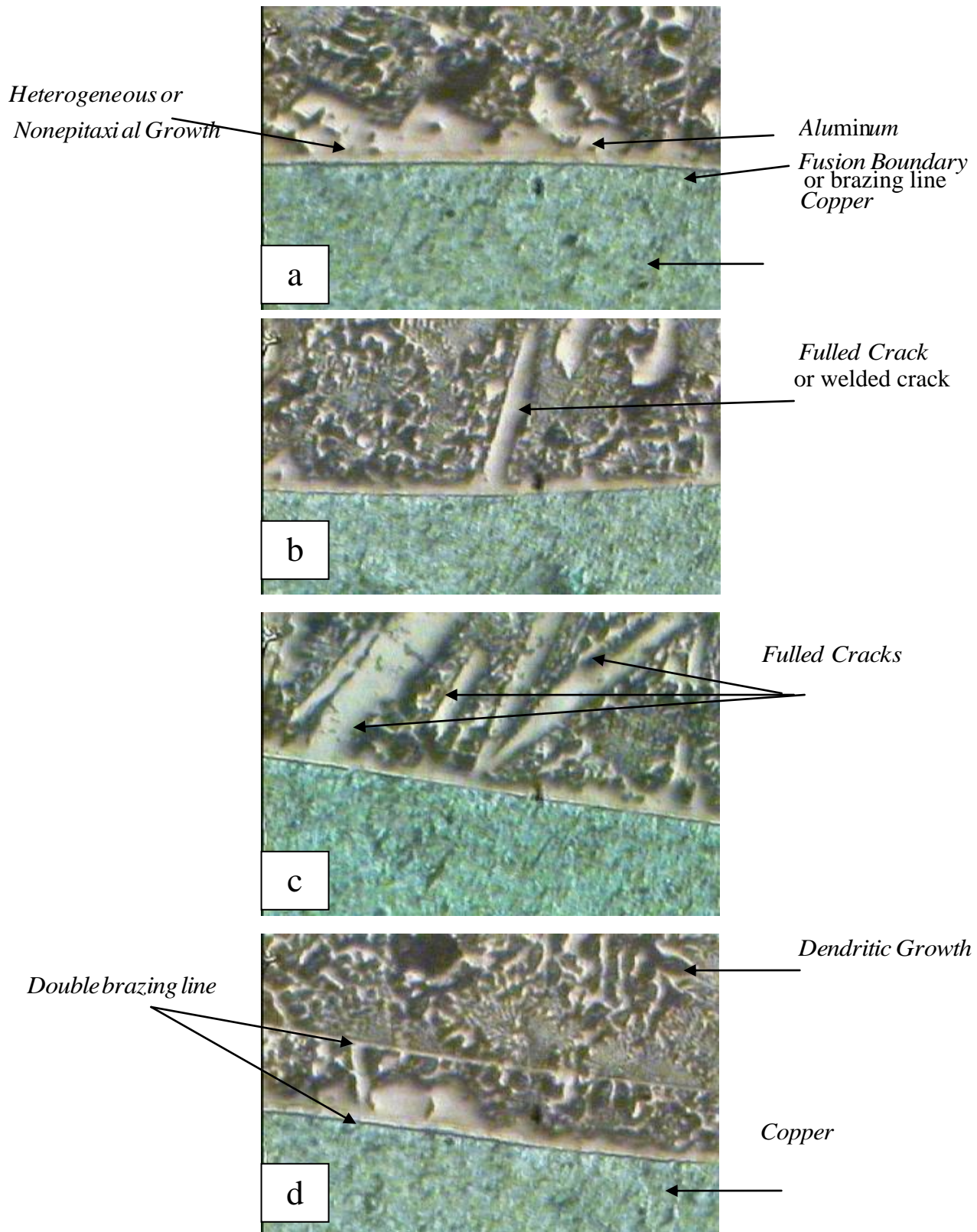
Results and Discussions:

When welding with a filler metal (or joining two different materials), the weld metal composition is different from the base metal composition, and the weld metal crystal structure can differ from the base metal crystal structure. When this occurs, epitaxial growth is no longer possible and new grains will have to nucleate at the fusion boundary. Figure (3) shows the brazing boundary microstructure, which shows that the copper side with braze filler, and some fusion of aluminum

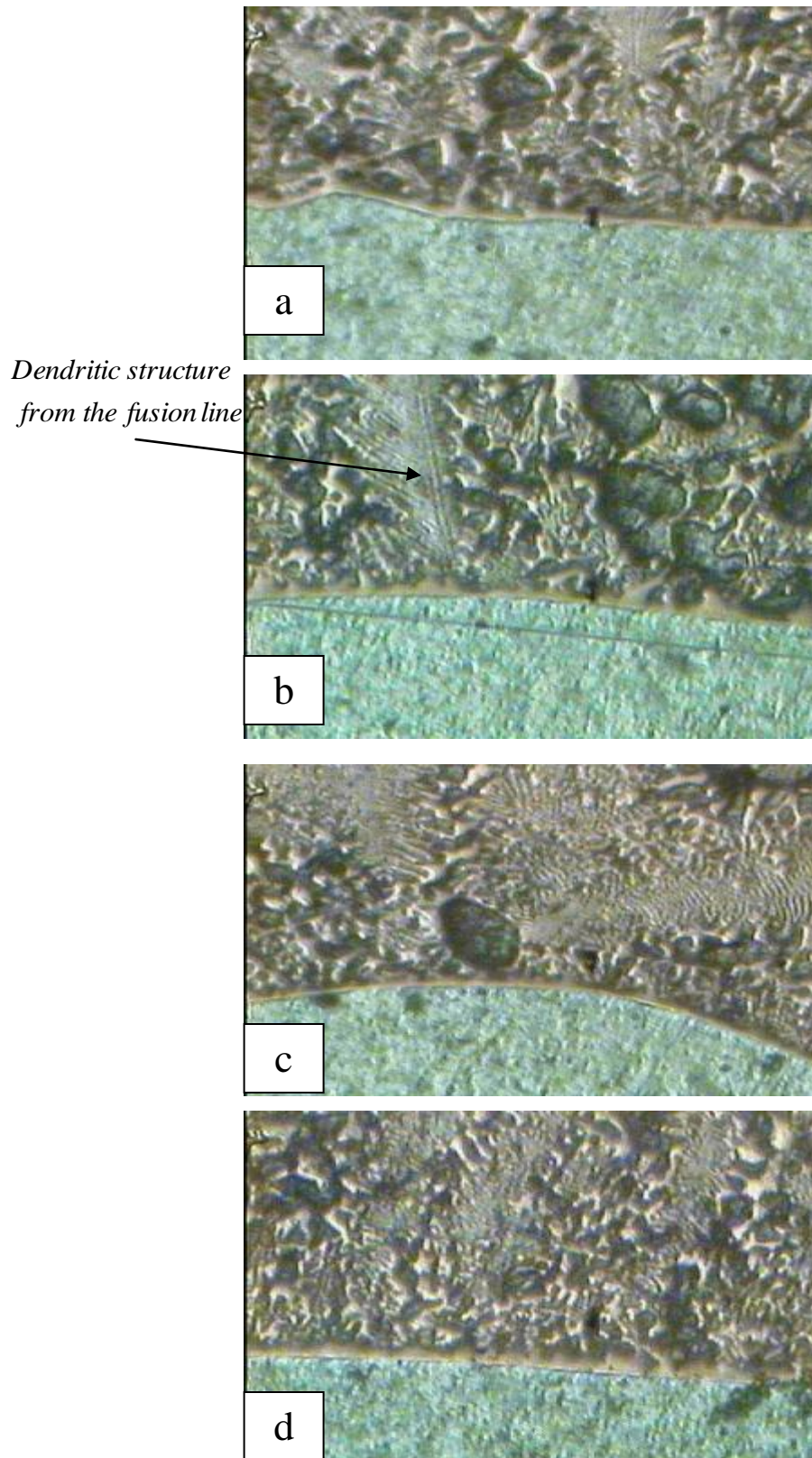
will exhibit two different crystal structures at the solidification temperature, nucleation of solid weld metal occurs on heterogeneous sites on the partially melted base metal at the fusion boundary. Figure (4) shows the cracks creations, and the mechanism for fulling these crack by the braze capillary action at the final range of brazing temperature, which the filler and copper side been solidies, and the final fluid of filler and aluminum will make closing these cracks immediately. Figure (4a) shows the beginning of the previous process. Figure (4b) shows the initiation of crack due to the dissimilarity between copper and aluminum. So the final stage of this process is to moving that liquid of filler, which is mixed with aluminum to make a good reaction with the two sides of these cracks as shown in figure (4c). Figure (4d) shows two brazing line, which means that fusion line may transfer to another portion at this process. Figure (5a,b,c and d) shows that this process is done with a dendritic structure at the aluminum side, which started from the brazing line. By comparing the above conclusions with the fusion welding by oxyacetylene welding, can be explain as in figure (6) which shows the fusion structure, which contains a grains with some mixing phase of two melted metals (copper and aluminum). There is no clearing for dendritic structure as was obtained in figure (3), and also there are some defects due to dissimilarity bonding. Figure (7) shows cracks at the aluminum side but with no fulling process as shown in figure (4).



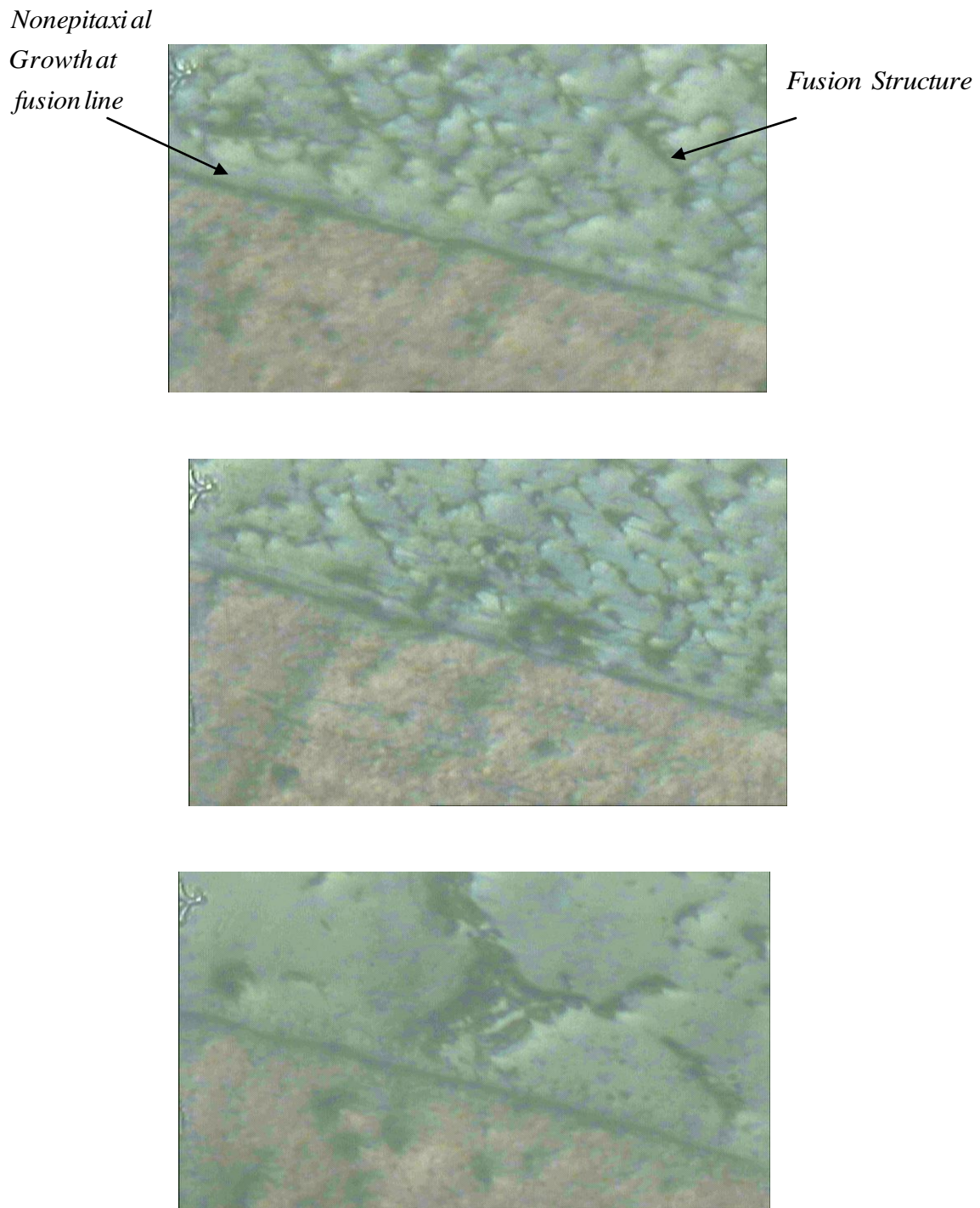
Figure(3): Nonepitaxial growth at the brazing boundary, X100.



Figure(4): a- Nonepitaxial growth, b- Crack initiation at the brazing line. c- multy cracks at the brazing line, d-double brazing line, X100.

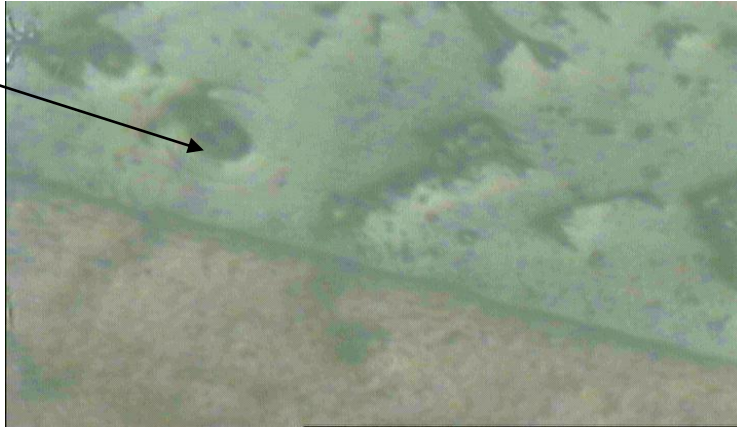


Figure(5): Dendritic structure starting perpendicular to the brazing line, X100.

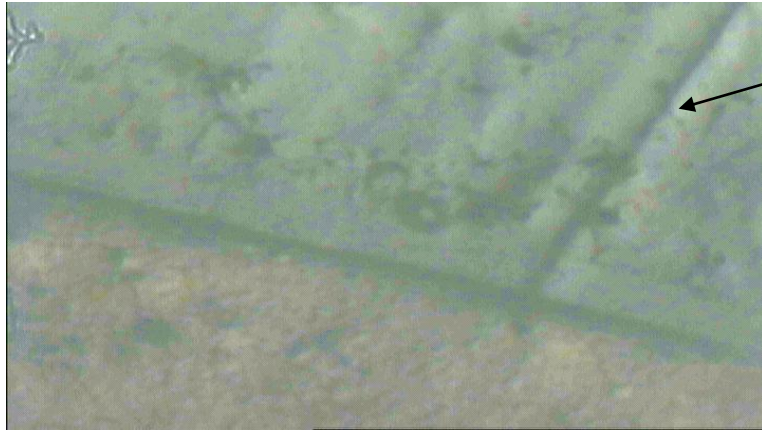


Figure(6): Nonepitaxial growth with heterogeneous structure in fusion welding of copper to aluminum by oxyfuel gas welding process, X100

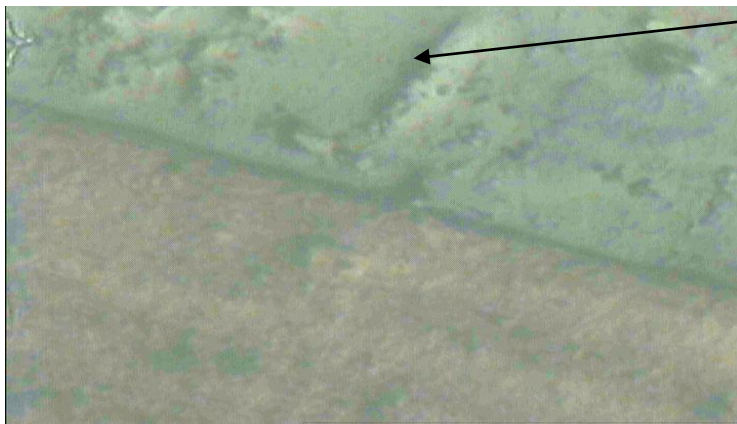
Defect



Crack



Crack



Figure(7) Cracks at the fusion line in fusion welding of copper to aluminum by oxyfuel gas welding process, X100.

Conclusion:

The solid conclusion which have brought by this work is that cracks which held by welding due to dissimilar joining can be welded by the brazing remediation with capillary action at the final stage of brazing. This result can be used to preparing different types of dissimilar joints which are difficult to welded by usual welding process.

References:

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