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European project CSI: Central Nervous System Imaging

TSV process modules development

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Introduction

Diseases affecting the brain and the central nervous system (Alzheimer's, Parkinson's) are among those with the greatest impact on our society. Prevention and early diagnosis are very effective, but the equipment and procedures employed are currently too expensive for general application. The European ENIAC JU project CSI aims to advance the state of the art in three-dimensional (3D) medical-imaging platforms to improve the efficiency of the diagnosis and therapy of these serious diseases.

Challenges and methods

Nowadays, specific issues arise with the temperature and stress sensitivity of detector devices. During the assembly process the components already suffer from a stress cycle that appears during the soldering process. The present lead-free solder is, compared to the former eutectic solder not very compliant, in the sense of stress relaxation. For that purpose work on low temperature interconnect processes is needed.

An investigation has been carried out for low temperature alloys which may be used for TSV interconnect. A list of candidate alloys has been established. These alloys are obviously lead-free alloys that consist of the following elements: Indium, Bismuth, Tin, Zinc and Silver. The lowest melting temperature is 70° C and the highest is 140° C.
During further research various physical and mechanical properties of these alloys, i.e. melting temperature (eutectic alloys) or melting temperature range, electrical conductivity, thermal conductivity, thermal coefficient of expansion, elongation, shear strength, creep behavior, hardness, wettability, latent heat of fusion and specific heat solid/liquid will be investigated.

Low melting alloys

To achieve a low stress SiPM (Silicon Photomultiplier), low melting alloys are desired for soldering of SiPM on PCB. Indium (In) based alloys are the main group of the candidate low meting solders. However the mechanical properties of high In alloys are inferior. Adding other elements like Ag, Zn and Sn could cause a stronger alloy. Nine solders with a melting temperature and/or melting range between 70ºC and 140ºC have been selected for this study. Microstructure of these low melting solder alloys has been investigated.

Mechanical behavior of low melting alloys

Nine different low melting solder alloys were made in a controlled atmosphere with less than 1 ppm oxygen pressure. The nine different low melting solder alloys were casted in a mold with dimensions: 28x22 mm. The thickness of the casted solder was approximately 4 mm. Subsequently, the casted solder was cold rolled . Mechanical behavior and microstructure were qualified.

Solder alloy MT-100640 (In57Sn17Bi26) (a) SEM picture of microstructure at enlargement 1000x (b) alloy cold rolled until cracked (20% thickness reduction).

Table 2: CSI low melting solder alloys. Alloys are manufactured by Mat-Tech BV.

Alloy-ID	In	Bi	Sn	Zn	Ag	Composition	Mechanical behavior
MT-100508	78,5	21,5				In78,5Bi21,5	Soft
MT-100640	57	26	17			In57Bi26Sn17	Brittle
MT-100625	52,2	46		1,8		In52,2Bi46Zn1,8	Soft
MT-100511	51,2		45,5	1,8	1,5	In51,2Sn45,5Zn1,8Ag1,5	Moderate
MT-100289	51		49			In51Sn49	Soft
MT-100509	50	50				In50Bi50	Brittle
MT-100504	5	47	47		1	Sn47Bi47In5Ag1	Brittle
MT-100505	5	46	47		2	Sn47Bi47In5Ag2	Brittle
MT-100506	5	45	47		3	Sn47Bi47In5Ag3	Brittle

Conclusions

In the first year's framework of the CSI project, various low melting solder alloys were made. The microstructure and mechanical behavior of the solder alloys were studied by cold rolling. Amongst others, the following conclusion can be drawn from this investigation:

- Solder alloys MT-100508 (In78,5Bi21,5), MT-100625 (In52,2Bi46Zn1,8), MT-100289 (In51Sn49) show a relatively soft character regarding the mechanical behavior during cold rolling
- Solder alloy MT-100511 (In51.2Sn45Zn1.8Ag1.5) shows a promising mediate character regarding the mechanical behavior during cold rolling
- Solder alloy MT-100640 (In57Bi26Sn17), MT-100509 (In50Bi50), MT-100504 (Sn47Bi47In5Ag1), MT-100505 (Sn47Bi47In5Ag2) and MT-100506 (Sn47Bi47In5Ag3) show a relatively brittle character regarding the mechanical behavior during cold rolling

Future work

- Determining of melting point or range of the solder alloys
- Determining mechanical properties by applying required experiments
- Further alloying of In-based alloys to achieve the desired mechanical properties