

This document provides the DA5 responses to the "Stakeholder Consultation Questionnaire: Exemption No. 8(e)". The Consultation was announced on 29-May-2018 and concludes on 24-July-2018.

The DA5 (Die Attach 5) consortium, members are Bosch (Division Automotive Electronics), Infineon Technologies, Nexperia, NXP Semiconductors and STMicroelectronics, was founded by semiconductor suppliers to jointly address and mutually define the direction of Pb-free solder d/a-technology. DA5 is working together with leading international material suppliers to find feasible alternative solutions for lead-free die-attach, to evaluate available and potential alternatives. The DA5 prioritize drop-in solutions but is also looking into solutions requiring package/chip changes.

General requirements to Die Attach materials are collected in the "DA5 Die-Attach Material Requirement Specification" document which is available upon request at DA5. Lead-free solutions have to fulfill those in the same way as leaded solutions do already.

Target: Identification of sustainable, enduring, standardized, reliable and dependable solutions for our customers

The DA5 consortium aims to lead the industry into the next phase of the lead-free semiconductor evolution. In this way the DA5 companies are also actively supporting the demands of the European Union towards reduced lead in electronics.

Consultation Questionnaire Exemption No. 8(e)

1. Please explain whether the use of lead in the application addressed under Ex. 8(e) of the ELV Directive is still unavoidable so that Art. 4 (2) (b) (ii) of the ELV Directive would justify the continuation of the exemption. Please be specific with your answer, for example clarify, if applicable, what types of vehicles your answer refers to, i.e., conventional vehicles and various types of hybrid and electric vehicles, and which functionalities and applications the exemption still needs to cover.



In general terms, the usage of LHMTS is still unavoidable since till now no replacement material was identified by the DA5 consortium. Substantial development efforts have been running for more than 9 years involving leading international material suppliers on a global base. While the DA5 consortium has not yet found a reliable lead-free package technology for power semiconductor components, the research is promising for long-term solutions.

The DA5 consortium expects that in the next decade more and more devices using newly available lead-free materials will enter the market for limited applications. The driving factor will be a dedicated performance upgrade for packages using lead-free materials already rather than the replacement of LHMTS. As already stated above, those same materials are promising candidates with a good evolution but not yet capable enough for the full scope of replacement of LHMTS with all its capabilities (e.g. reliability). Still, this trend will further enhance the development of die attach materials towards lead replacement for power devices.

Since the quality requirements AEC Q100 and AEC Q101 are valid for all automotive applications a differentiation between conventional and electric cars is not appropriate.

2. Please explain the efforts your organization has undertaken to find and implement the use of lead-free alternatives for automotive uses. Please refer to alternatives, which at least reduce the amount of lead applied or eliminate its necessity altogether.



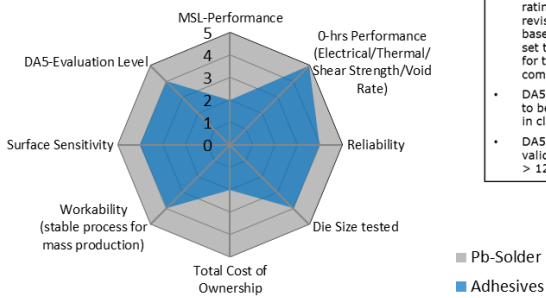
The DA5 consortium was initiated 2009 and is working on a lead-free die-attach solution since then. Substantial effort has been conducted in close cooperation with leading international material suppliers. In the meantime, more than one hundred material versions in four material classes (Adhesives, Ag Sintering, Transient Liquid Phase Sintering, Alternative Solder) have been evaluated with extensive efforts during sample preparation, workability testing, reliability testing and failure analysis.

None of the investigated alternatives was yet able to fulfill the required performance to replace LHMPs for die attach.

The latest DA5 results are summarized by the spider diagrams:

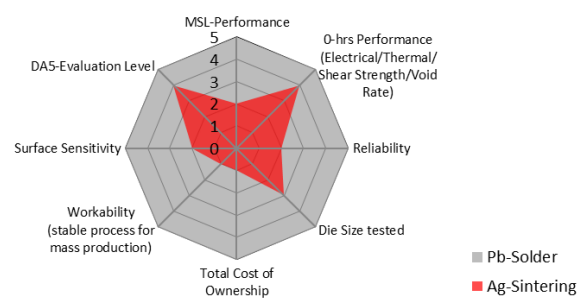


Adhesives vs. Pb-solder



(rating: 0 unknown, 1 very poor, 2 poor, 3 fair, 4 good, 5 very good: as good as Pb-solder)

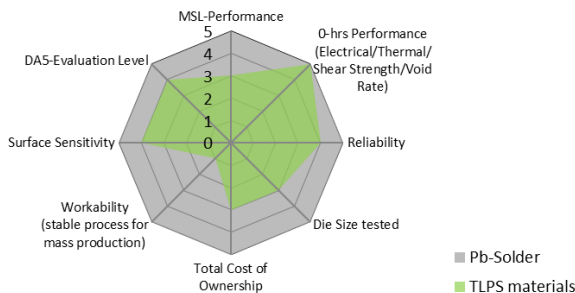
Ag Sintering vs. Pb-solder



(rating: 0 unknown, 1 very poor, 2 poor, 3 fair, 4 good, 5 very good: as good as Pb-solder)

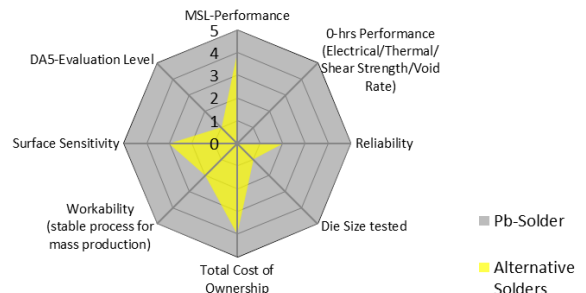
- DAS now uses a new rating system with revised criteria (Pb based solder reference set to 5 for all criteria) for the technology comparison
- DAS assessment refers to best tested material in class
- DAS assessment only valid for die thickness > 120 µm

TLPS materials vs. Pb-solder



(rating: 0 unknown, 1 very poor, 2 poor, 3 fair, 4 good, 5 very good: as good as Pb-solder)

Alternative Solders vs. Pb-solder

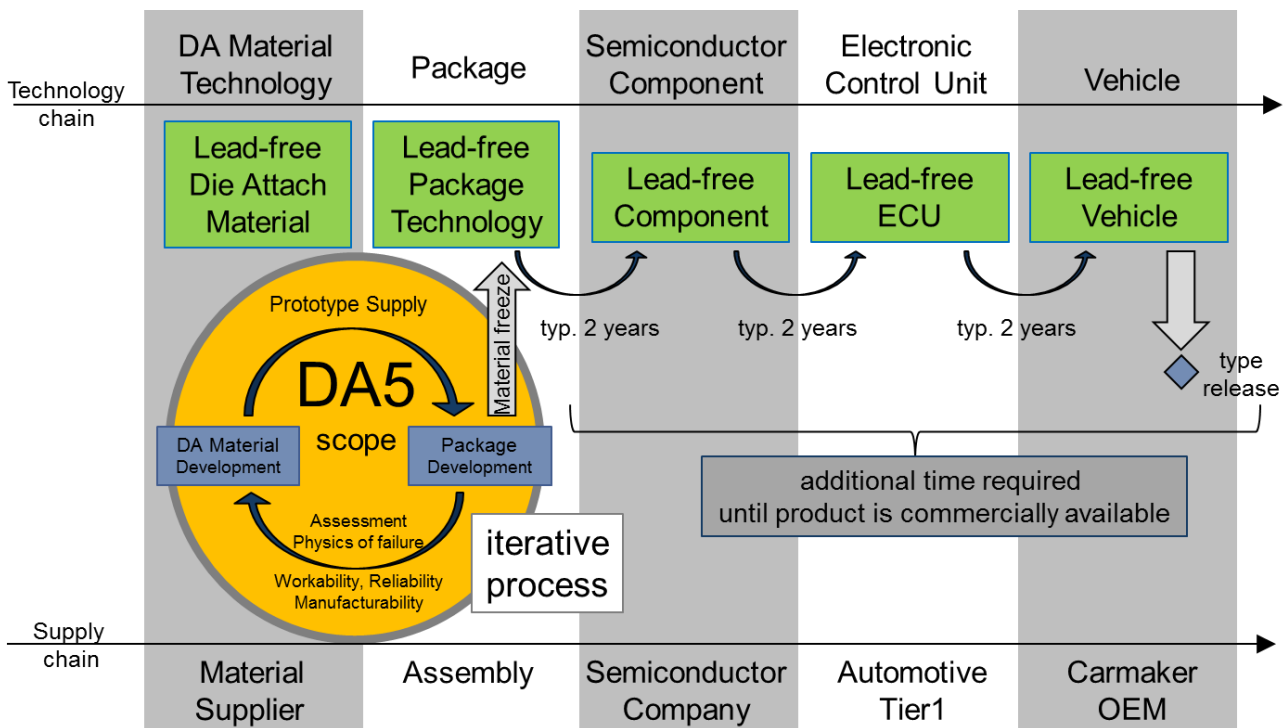


(rating: 0 unknown, 1 very poor, 2 poor, 3 fair, 4 good, 5 very good: as good as Pb-solder)

3. Please provide a roadmap specifying the necessary steps/achievements in research and development including a time scale for the substitution or elimination of lead in this exemption.



The DA5 consortium is working with leading international material suppliers on the development of an appropriate replacement for lead solder (DA5 scope). The properties of the needed die-attach material is specified in the “DA5 Die-Attach Material Requirement Specification” document which is provided to the material suppliers. DA5 encourages suppliers to offer their new materials, which are then evaluated by a DA5 company in cooperation with the supplier. Regular Face-to-face meetings are conducted to exchange and interpret the results in detail with the material suppliers. Common findings serve as basis for further optimization of the materials (development loop). The overall achievements are regularly published by DA5 (Customer Presentation). Once a capable material is finally identified and its composition is fixed, another 6 years will be required to qualify the new material through the whole supply chain. Based on current status, DA5 cannot predict a date for customer sampling.



4. What is the amount of lead that would be contained in LHMTS in vehicles
- placed on the EU market
 - worldwide

in case the exemption is continued? Please provide a substantiated estimate clarifying how you have arrived at the stated result.



Please see calculation of ACEA association.

5. Overall, please let us know whether you agree with the necessity to continue the exemption and sum up your arguments for or against its continuation.



The exemption of using lead solder in the die attach is still a requirement, because until today there is no solution available that can substitute LHMTS based die attach materials. However, DA5 consortium will continue to work extensively in cooperation with leading international material suppliers to identify lead-free alternatives to LHMTS based die attach.

Conclusion



- Today's lead-free material technologies for semiconductor applications (die attach) are not ready to substitute Leaded High Melting Temperature Solders as drop-in solution.
- Substantial development efforts have been running for more than 9 years. While the DA5 consortium has not yet found a reliable lead-free package technology for power semiconductor components, the research is promising for long-term solutions.
- Material evaluations continue in close cooperation with leading international material suppliers, but semiconductor component qualifications, material supplier conversions and equipment conversions can only begin after a reliable lead-free package technology for replacement is available.
- Customer qualifications (TIER1 and OEM) and supply chain conversion / ramp can only begin after package technology and semiconductor component qualification.
- No single drop-in lead-free solution is in sight! Different applications will need different solutions. It's likely that some application fields will not be covered by lead-free solutions and therefore need continued exemption.
- Based on current status, DA5 cannot predict a date for customer sampling. As shown in the previous slide, the release process will take a substantial amount of time.