QUALSi project – task plan (v 1.02 updated January 4, 2023)

The individual **topics / questions (A to X)** that are processed within the scope of individual **tasks (1 to X)** are listed starting from the next page. A topic can be processed several times with different boundary conditions **(topic A.1, topic A.2, topic A.3, ...)**, e.g. with changing material combinations. The tasks for which sufficient partners could be recruited are processed in ascending order. The processing of the tasks in a different order is generally not intended. If this step becomes necessary, it will be done in consultation with the project partners. Changing the order of tasks for which partners have not yet been recruited (**yellow** and **red** in the **project barometer**) is possible at any time and is sometimes necessary to recruit new partners or readjust the project goals.

Topics / Questions

(A) Are AlSi1 thin wires with Ni content basically the better choice in terms of process window and corrosion resistance? (A.1, A.2)

(B) How big is the difference between soft and hard AlSi1 thin wire types in terms of bonding behavior and reliability? (B.1)

(C) What are the differences between different wire manufacturers? (C.1)

(D) What deviations in the wire bonding process can be expected with batch variations of the bonding wire (breaking load, elongation)? (D.1)

(E) What changes in the mechanical properties of AlSi1 thin wires can be expected after exposure to temperature? (E.1)

(F) How high is the risk when using (too) old wires? (F.1)

(G) What influence do wire diameter (AlSi1 thin wire) and material have on the size of the bonding parameter process window? (G.1, G.2, G.3, G.4, G.5)

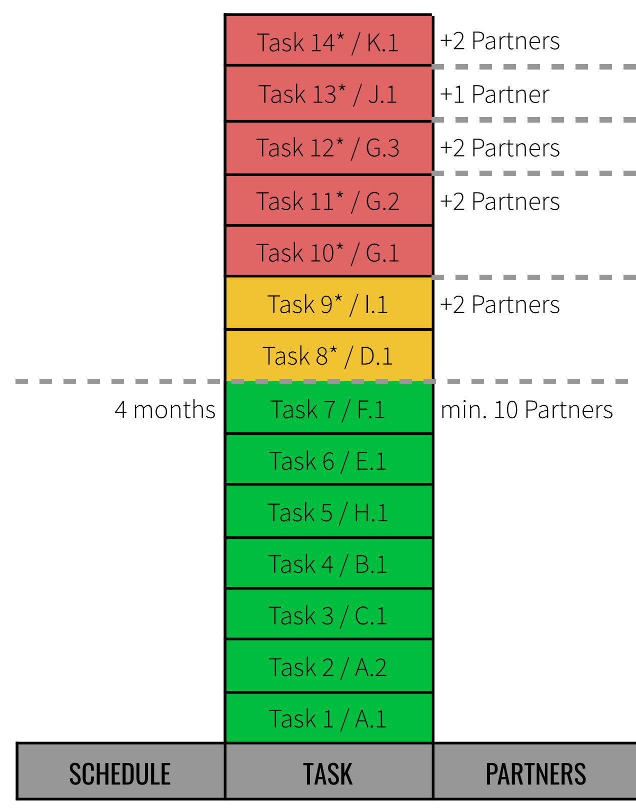
(H) What is the difference between 25 µm and 50 µm AlSi1 thin wire in terms of reliability/lifetime under cyclic mechanical load? (H.1)

(I) How much do bond and loop parameters need to be adjusted in case of material changes/variations of AlSi1 thin wires? (I.1)

(J) How strong is the impact of different wire elongations (at the same breaking load of the AlSi1 thin wire) on the wire bonding process characteristics? (J.1)

(K) How strong is the impact of different wire elongations (at the same breaking load of the AlSi1 thin wire) on the reliability/lifetime under cyclic mechanical load? (K.1)

Project barometer



*The order of these tasks can change. Proposals for changes will be submitted to the project partners.

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Task (1 – x)*	Topic (A1 – Zx)	Short Description of Topic / Question	Substrate	Wire	Studies performed
1 ✅ not started	**A.1**	**(A)**: Are AlSi1 thin wires with Ni content basically the better choice in terms of process window and corrosion resistance? **→ focus: 50 µm wire on ENEPIG**	PCB / ENEPIG	50 µm AlSi1 Standard and AlSi1 + Ni of one supplier	• DoE process window analysis (pull testing, deformation measurement) • Analysis of deformation traces in the wire bonder • Comparative risk assessment of heel damage (buckling load in the heel area at 3 loop settings, pull tests and SEM analysis for evaluation) • 85°C @ 85% rel. humidity ageing, sampling in 4 intervals (SEM and pull tests to determine a potential degree of damage)
2 ✅ not started	**A.2**	**(A)**: Are AlSi1 thin wires with Ni content basically the better choice in terms of process window and corrosion resistance? **→ focus: 25 µm wire on ENIG**	PCB / ENIG	25 µm AlSi1 Standard and AlSi1 + Ni of one supplier	• DoE process window analysis (pull testing, deformation measurement) • Analysis of deformation traces in the wire bonder • Comparative risk assessment of heel damage (buckling load in the heel area at 3 loop settings, pull tests and SEM analysis for evaluation) • 85°C @ 85% rel. humidity ageing, sampling in 4 intervals (SEM and pull tests to determine a potential degree of damage)
3 ✅ not started	**C.1**	**(C)**: What are the variations between different wire manufacturers? **→ focus: to be defined by material selection and available manufacturers**	PCB / ENEPIG	50 µm AlSi1 standard or with Ni from supplier A and B (same specification)	• DoE process window analysis (pull testing, deformation measurement) • Analysis of deformation traces in the wire bonder • Comparative risk assessment of heel damage (buckling load in the heel area at 3 loop settings, pull tests and SEM analysis for evaluation) • Loop shape analysis (height measurement and video analysis from side view during bonding

not started in progress completed ✅ will be processed as soon as **10 project partners** participate

*processing of the individual studies according to task numbering

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Task (1 – x)*	Topic (A1 – Zx)	Short Description of Topic / Question	Substrate	Wire	Studies performed
4 ✅ not started	**B.1**	**(B)**: How big is the difference between soft and hard AlSi1 thin wire types in terms of bonding behavior and reliability? **→ focus: to be defined by material selection**	PCB / ENEPIG	50 µm AlSi1 hard and soft wire (standard or with Ni) of one supplier	• DoE process window analysis (pull testing, deformation measurement) • Analysis of deformation traces in the wire bonder • Mechanical cycling tests (piezo cycling stand with defined stroke): comparable loop geometry and wedge deformation, monitoring of the decrease in mechanical strength by a pull test, analysis of heel areas and weakened regions on SEM (comparison of 2 loop geometries and 2 strokes)
5 ✅ not started	**H.1**	**(H)** What is the difference between 25 µm and 50 µm AlSi1 thin wire in terms of reliability/lifetime under cyclic mechanical load? **→ focus: to be defined by material selection**	PCB / ENEPIG	25 µm and 50 µm AlSi1 wire of one type (type to be defined during the project – hard/soft, standard/Ni) of one supplier	• Bonding with individually optimized bonding parameters • Mechanical cycling tests (piezo cycling stand with defined stroke): comparable loop geometry and wedge deformation, monitoring of the decrease in mechanical strength by a pull test, analysis of heel areas and weakened regions on SEM (comparison of 2 loop geometries and 2 strokes)
6 ✅ not started	**E.1**	**(E)** What changes in the mechanical properties of AlSi1 thin wires can be expected after exposure to temperature? **This task is performed with any new material available in the project.**	PCB / ENEPIG	All wires used during the project	• Bond tests with high sample size with individually optimized and constant bonding parameters (pull tests are performed in initial state after bonding) • Temperature aging at 3 temperatures (120°C, 150°C, 175°C) for 30 min, 1 h, 2 h, 10 h (pull tests after aging)
7 ✅ not started	**F.1**	**(F)** How high is the risk when using (too) old wires? **→ focus: 50 µm AlSi1 wire**	PCB / ENEPIG	50 µm 3 conditions of an AlSi1 wire type (fresh, in the range of the best-before date, 3+ years) of one supplier	• DoE process window analysis (pull testing, deformation measurement) • Analysis of deformation traces in the wire bonder • Bond tests with high sample size with individually optimized and constant bonding parameters (pull tests to check for unexpected outliers, analysis of outliers)

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Task (1 – x)*	Topic (A1 – Zx)	Short Description of Topic / Question	Substrate	Wire	Studies performed
8 not started	**D.1**	**(D)** What deviations in the wire bonding process can be expected with batch variations of the bonding wire (breaking load, elongation)? **→ focus: 50 µm AlSi1 wire (batches to be analyzed will be defined during the project)**	PCB / ENEPIG	50 µm AlSi1 thin wire of three (3) production batches with slight differences in breaking load and elongation of one supplier	• Bond tests with high sample size with constant bonding parameters (pull test and deformation measurement) • Comparative risk assessment of heel damage (buckling load in the heel area at 3 loop settings, pull tests and SEM analysis for evaluation) • Analysis of deformation traces in the wire bonder
9 not started	**I.1**	**(I)** How much do bond and loop parameters need to be adjusted in case of material changes/variations of AlSi1 thin wires? **→ focus: 50 µm AlSi1 wire, same wire as used in task 8**	PCB / ENEPIG	50 µm AlSi1 thin wire of three (3) production batches with slight differences in breaking load and elongation of one supplier	• Individual bonding and looping parameter adjustments until pull test results and loop shape for all wires are within a pre-defined tolerance • Adjustment of bonding parameters until deformation traces of the wire bonder are within a pre-defined tolerance
10 not started	**G.1**	**(G)** What influence do wire diameter (AlSi1 thin wire) and material have on the size of the bonding parameter process window? **→ focus: standard AlSi1**	PCB ENEPIG and ENIG	25 µm and 50 µm AlSi1 standard of one supplier	• Comparative DoE for process window evaluation (pull test and deformation measurement) • Analysis of deformation traces in the wire bonder
11 not started	**G.2**	**(G)** What influence do wire diameter (AlSi1 thin wire) and material have on the size of the bonding parameter process window? **→ focus: corrosion resistant AlSi1 with Ni**	PCB ENEPIG and ENIG	25 µm and 50 µm AlSi1 with Ni of one supplier	• Comparative DoE for process window evaluation (pull test and deformation measurement) • Analysis of deformation traces in the wire bonder

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Task (1 – x)*	Topic (A1 – Zx)	Short Description of Topic / Question	Substrate	Wire	Studies performed
12 not started	**G.3**	**(G)** What influence do wire diameter (AlSi1 thin wire) and material have on the size of the bonding parameter process window? **→ focus: AlSi1 on Al-metallization**	Silicon with Al-metallization	25 µm and 50 µm AlSi1 with Ni of one supplier	• Comparative DoE for process window evaluation (pull test and deformation measurement) • Analysis of deformation traces in the wire bonder
13 not started	**J.1**	**(J)** How strong is the impact of different wire elongations (at the same breaking load of the AlSi1 thin wire) on the wire bonding process characteristics? **→ focus: AlSi1 thin wire with elongations at the lower and upper corners of the specification limits (typically 1% to 6% elongation)**	PCB / ENEPIG	50 µm AlSi1 with Ni low and high elongation of one supplier	• DoE process window analysis (pull testing, deformation measurement) • Analysis of deformation traces in the wire bonder • Comparative risk assessment of heel damage (buckling load in the heel area at 3 loop settings, pull tests and SEM analysis for evaluation)
14 not started	**K.1**	**(K)** How strong is the impact of different wire elongations (at the same breaking load of the AlSi1 thin wire) on the reliability/lifetime under cyclic mechanical load? **→ focus: AlSi1 thin wire with elongations at the lower and upper corners of the specification limits (typically 1% to 6% elongation)**	PCB / ENEPIG	50 µm AlSi1 with Ni low and high elongation of one supplier	• Bonding with individually optimized bonding parameters • Mechanical cycling tests (piezo cycling stand with defined stroke): comparable loop geometry and wedge deformation, monitoring of the decrease in mechanical strength by a pull test, analysis of heel areas and weakened regions on SEM (comparison of 2 loop geometries and 2 strokes)
15 not started	**G.4**	**(G)** What influence do wire diameter (AlSi1 thin wire) and material have on the size of the bonding parameter process window? **→ focus: standard AlSi1**	PCB ENEPIG	18 µm and 25 µm AlSi1 with Ni of one supplier	• Comparative DoE for process window evaluation (pull test and deformation measurement) • Analysis of deformation traces in the wire bonder

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Task (1 – x)*	Topic (A1 – Zx)	Short Description of Topic / Question	Substrate	Wire	Studies performed
16 not started	**G.5**	**(G)** What influence do wire diameter (AlSi1 thin wire) and material have on the size of the bonding parameter process window? **→ focus: AlSi1 on Al-metallization**	Silicon with Al-metallization	18 µm and 25 µm AlSi1 with Ni of one supplier	• Comparative DoE for process window evaluation (pull test and deformation measurement) • Analysis of deformation traces in the wire bonder

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