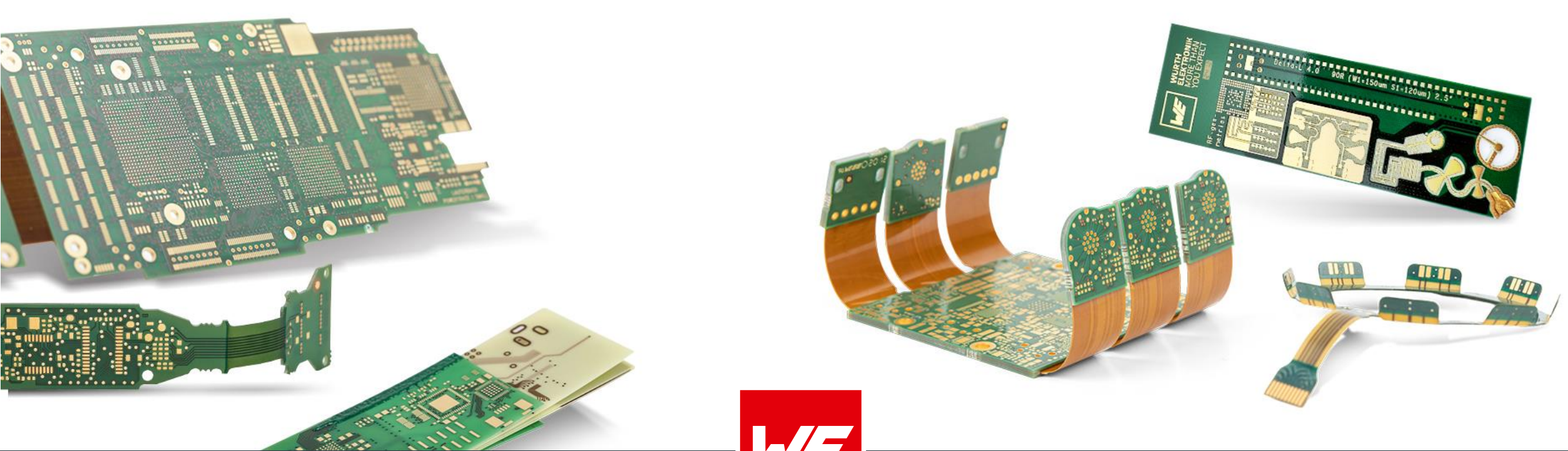
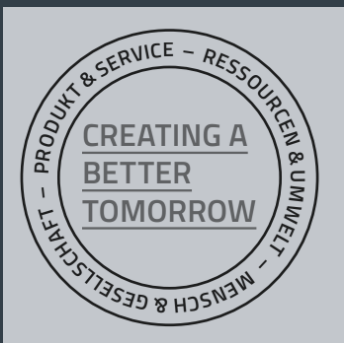




PCB TECHNOLOGY: SOLDER SURFACES

Bernd Schröder & Andreas Schilpp

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT



AGENDA

PCB technologies: Solder surfaces

1. Introduction to soldering surfaces - World market update
2. Development of solder surfaces
3. The most important surfaces in detail
 - Process, effort, sustainability
 - Advantages and disadvantages, storage, costs
 - Known risks in the field
4. Selection criteria
5. Overview: Recommendation for various applications
6. Outlook
7. Summary



Andreas Schilpp
Technical Marketing

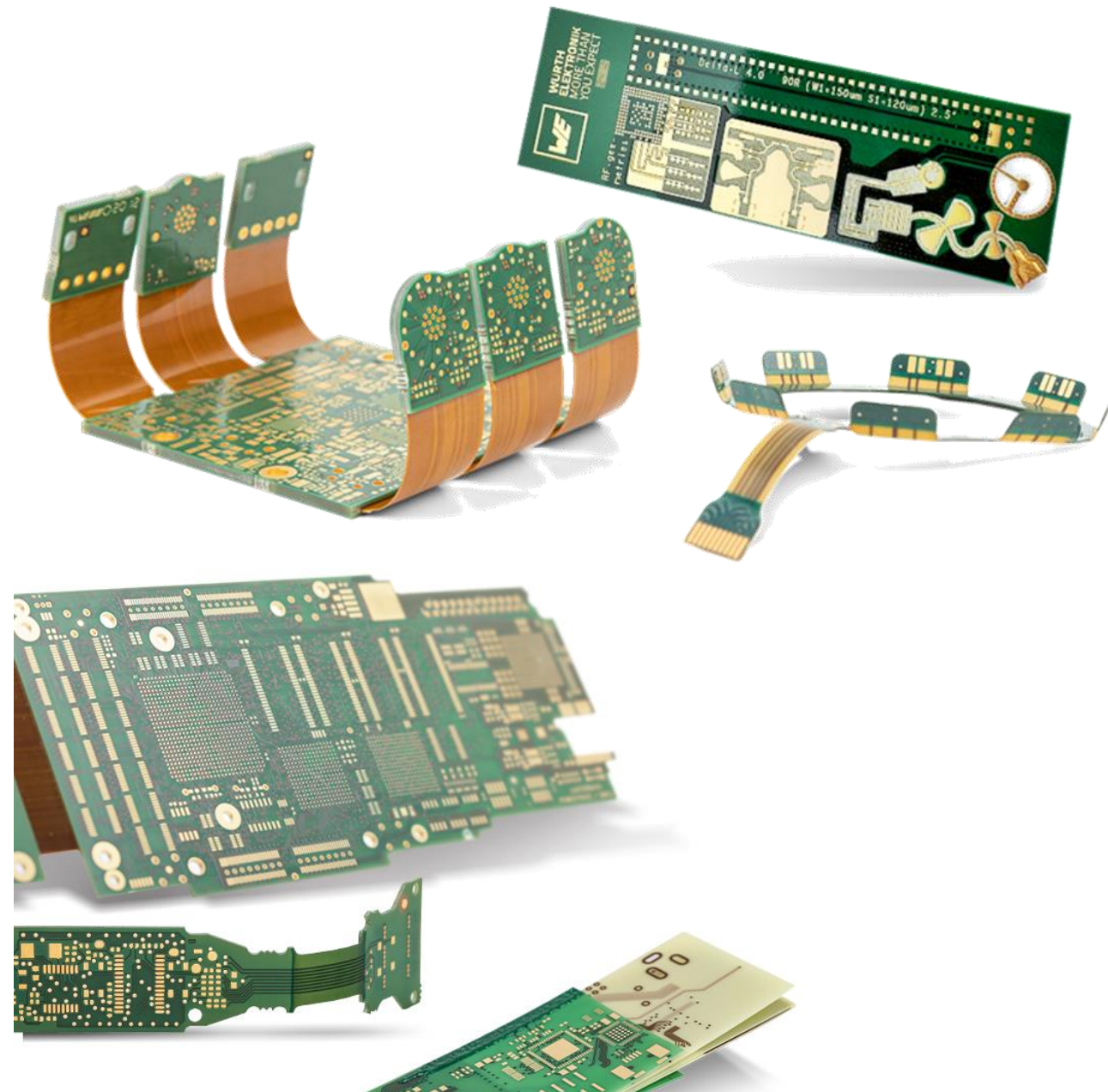


OUR PORTFOLIO

Wide range of technologies

- BASIC
- Flex solutions
- Microvia HDI
- Thermal management
- High current
- Printed Polymer
- Wire bonding and systems
- Embedding technology

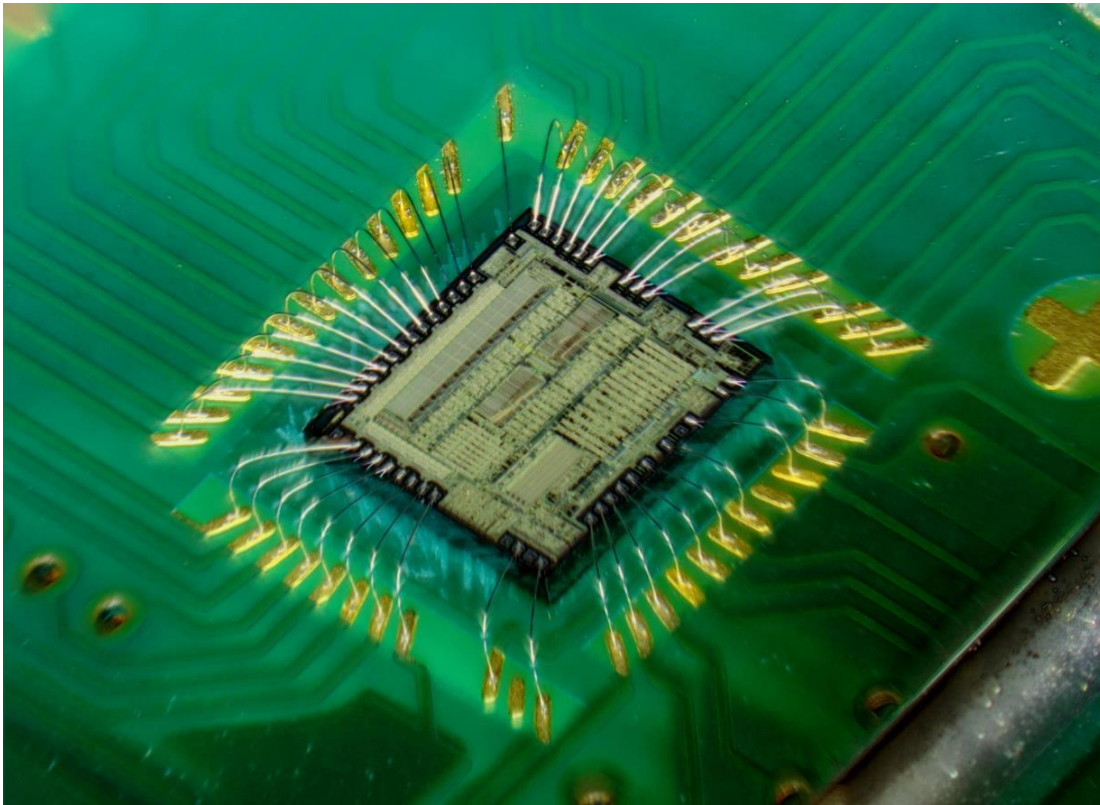
From samples from our online store to large series from Asia - also as a fast delivery service.



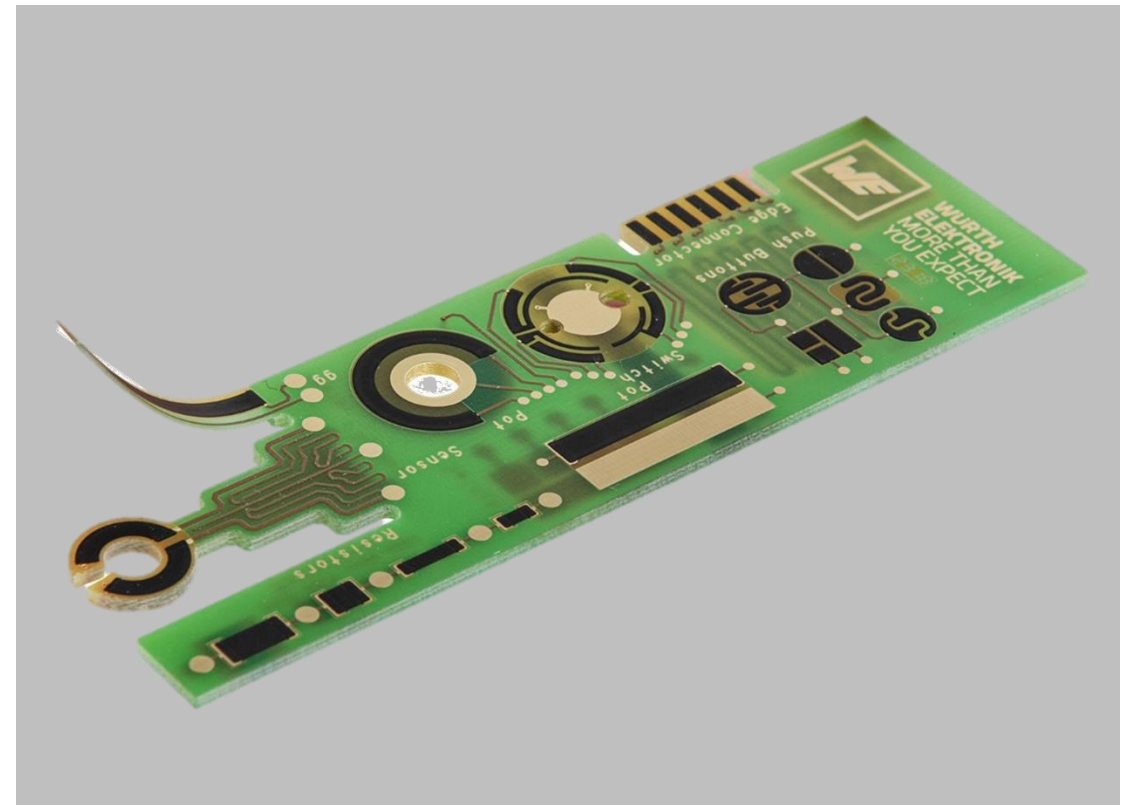
END SURFACES VERSUS SOLDER SURFACES

Scope of the topic - this webinar does not cover:

Wire bonding technology



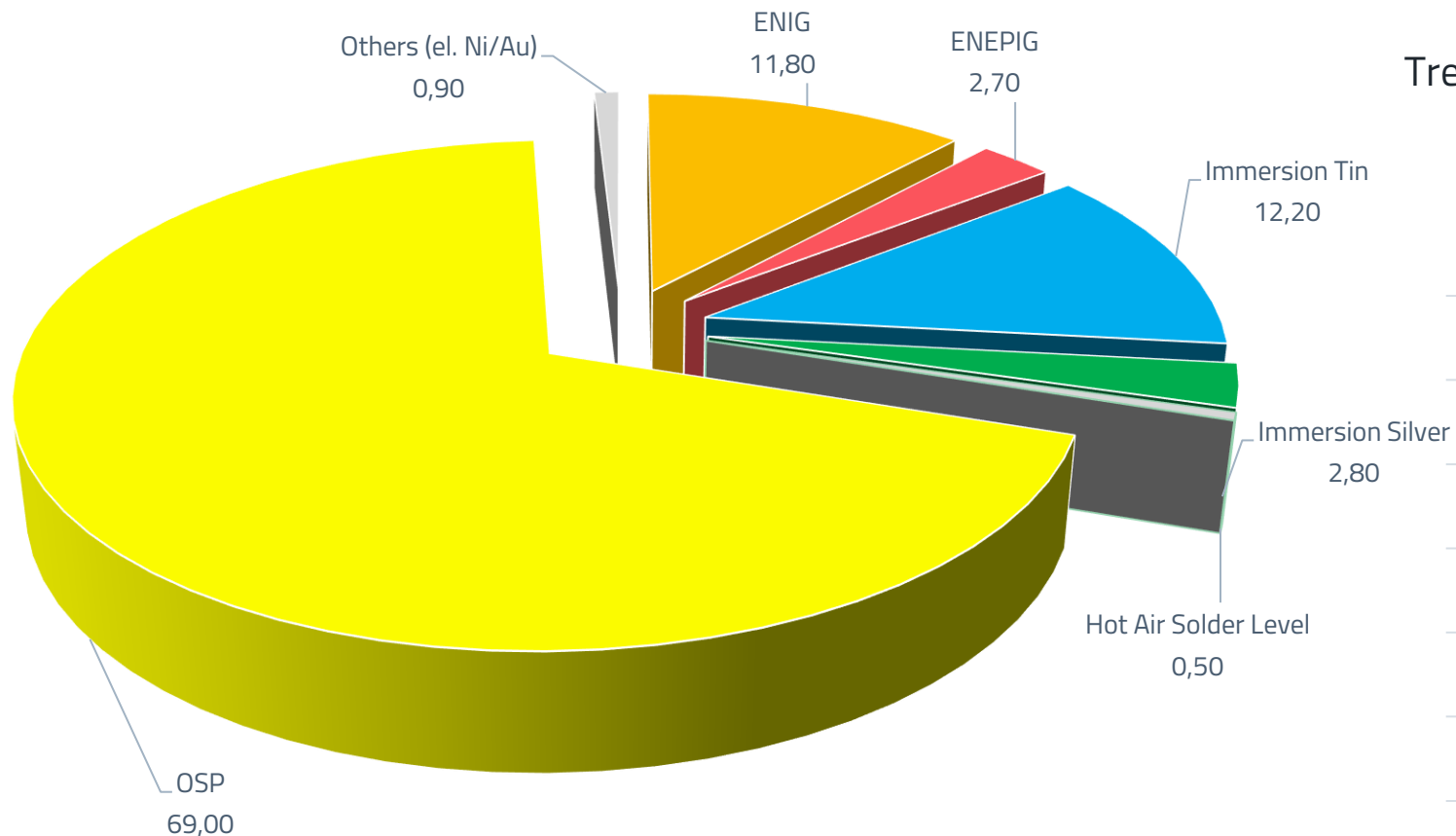
Polymer surfaces



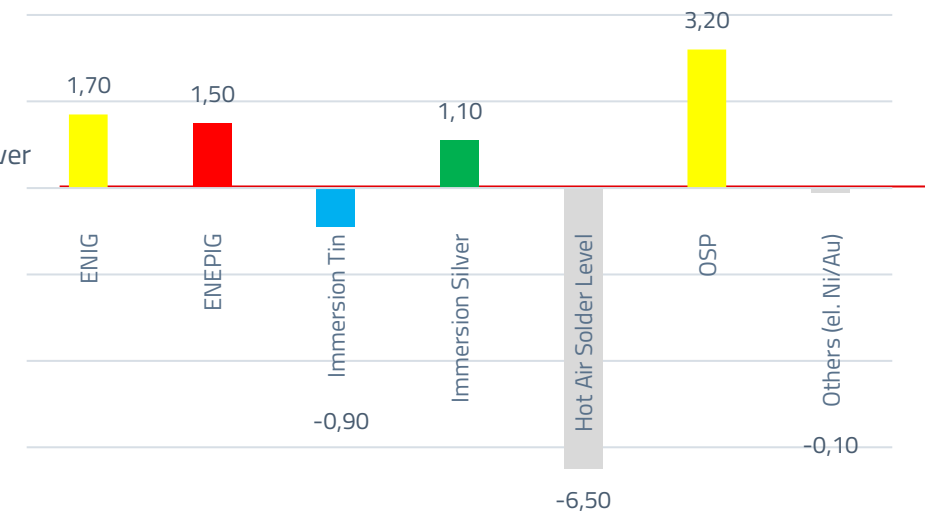
INTRODUCTION TO SOLDERING SURFACES - WORLD MARKET UPDATE

SOLDER SURFACES "TREND ANALYSIS"

Spread of end surfaces worldwide



Trend over the last 4 years (2019 to 2023) in %

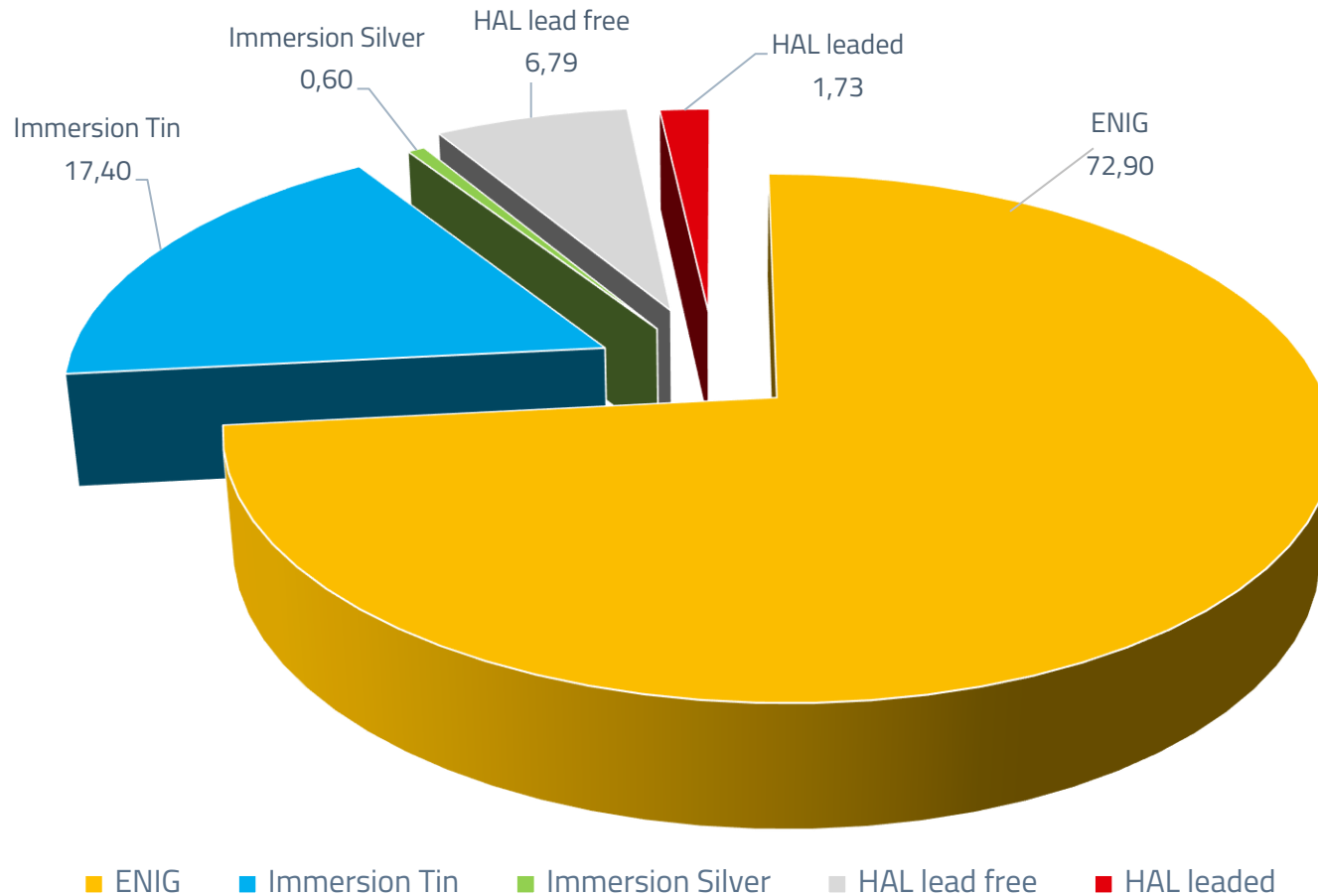


ENIG ENEPIG Immersion Tin Immersion Silver Hot Air Solder Level OSP Others (el. Ni/Au)

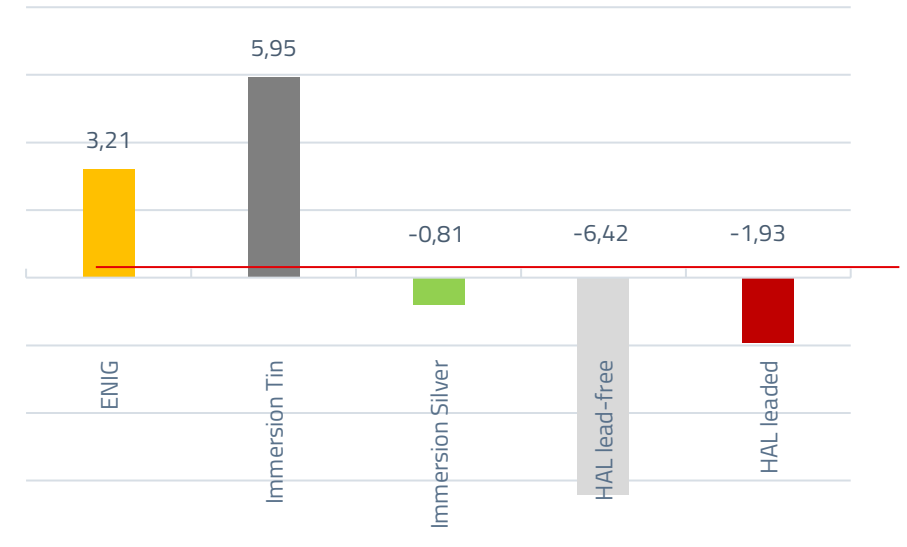
Source ZVEI Stand 2023

SOLDER SURFACES "TREND ANALYSIS"

Spread of end surfaces at Würth Elektronik



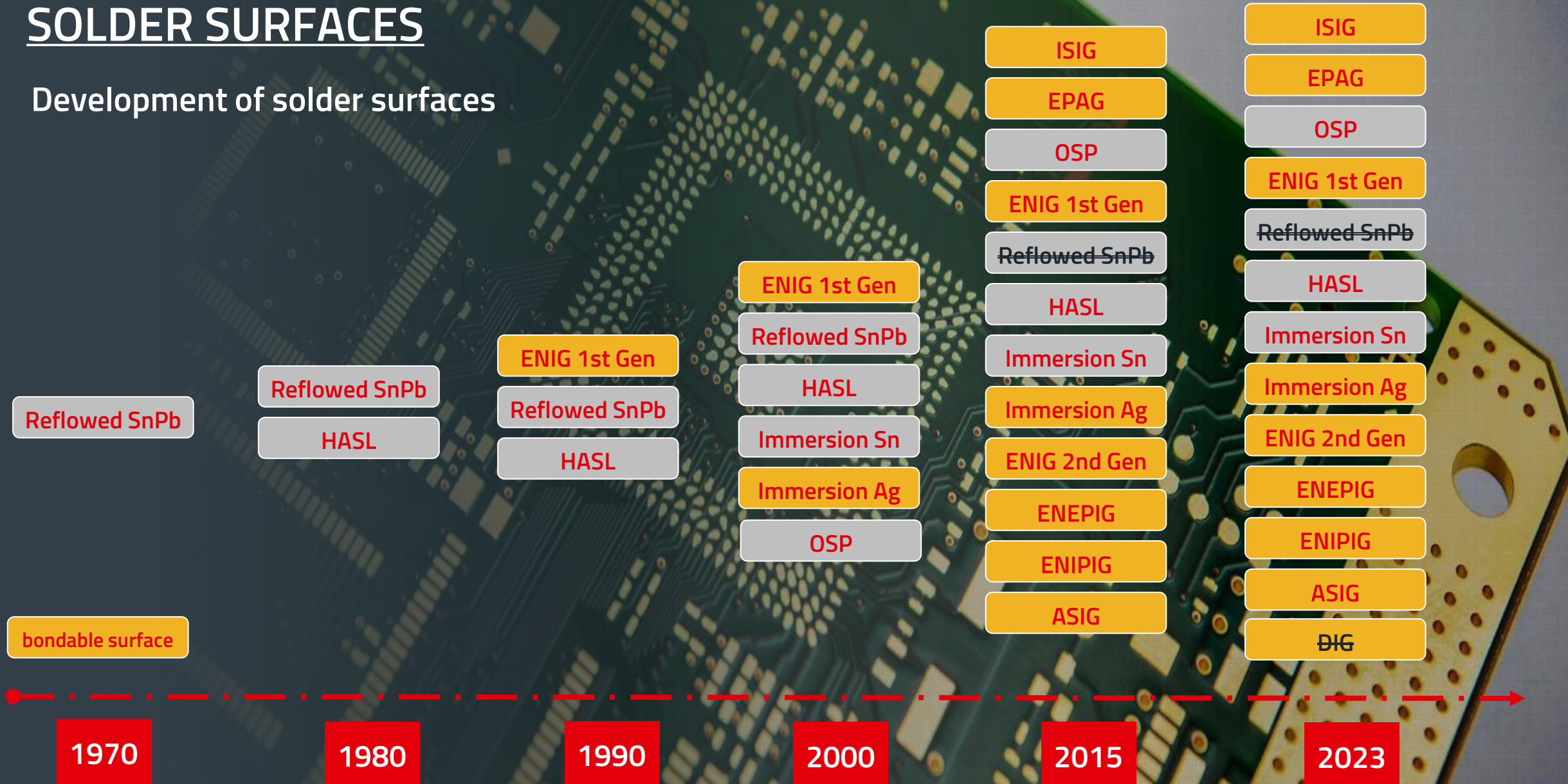
Trend over the last 4 years (2019 to 2023) in %



DEVELOPMENT OF SOLDER SURFACES

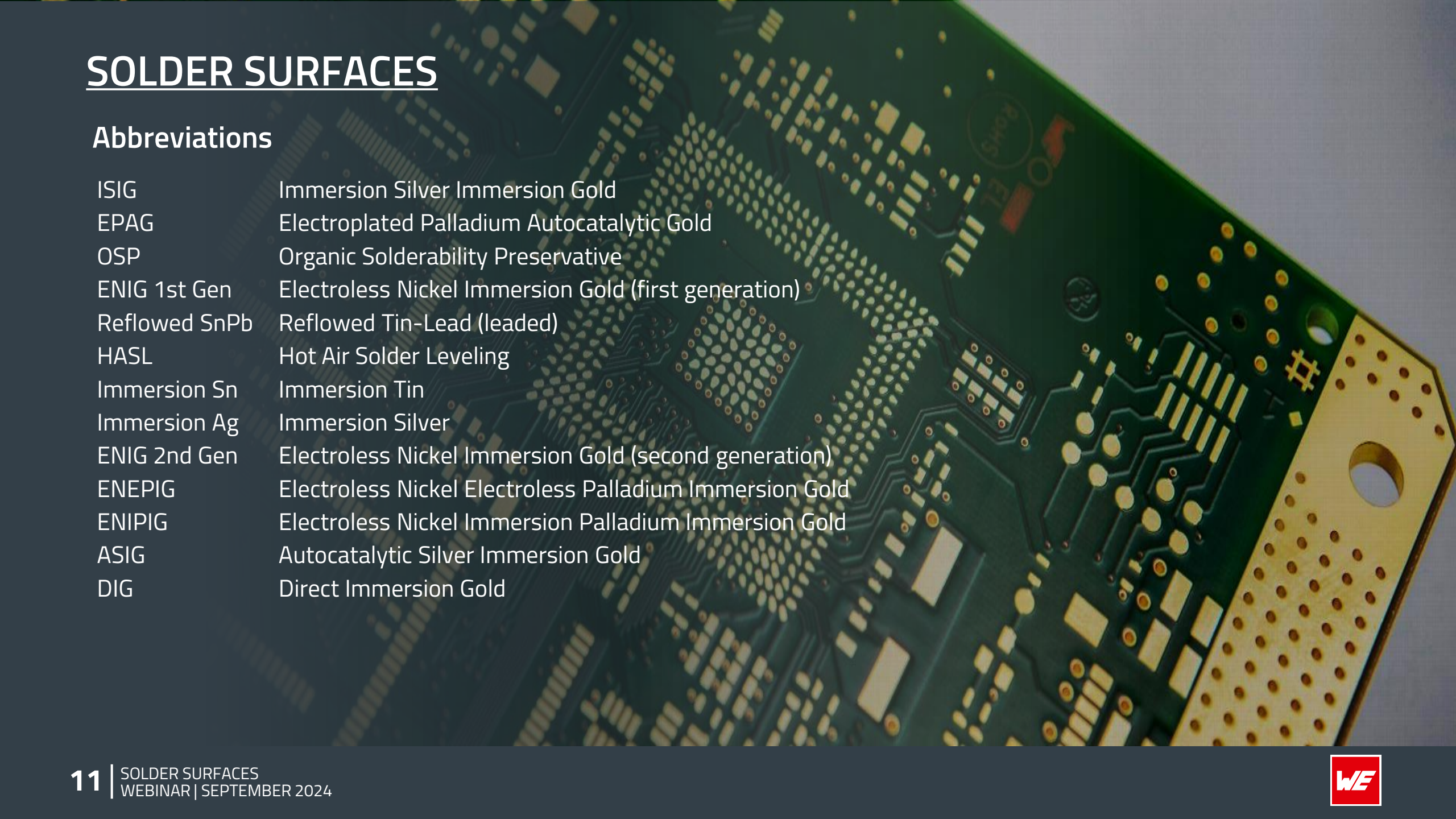
SOLDER SURFACES

Development of solder surfaces



SOLDER SURFACES

Abbreviations



ISIG	Immersion Silver Immersion Gold
EPAG	Electroplated Palladium Autocatalytic Gold
OSP	Organic Solderability Preservative
ENIG 1st Gen	Electroless Nickel Immersion Gold (first generation)
Reflowed SnPb	Reflowed Tin-Lead (lead)
HASL	Hot Air Solder Leveling
Immersion Sn	Immersion Tin
Immersion Ag	Immersion Silver
ENIG 2nd Gen	Electroless Nickel Immersion Gold (second generation)
ENEPIG	Electroless Nickel Electroless Palladium Immersion Gold
ENIPIG	Electroless Nickel Immersion Palladium Immersion Gold
ASIG	Autocatalytic Silver Immersion Gold
DIG	Direct Immersion Gold

THE MOST IMPORTANT SURFACES IN DETAIL

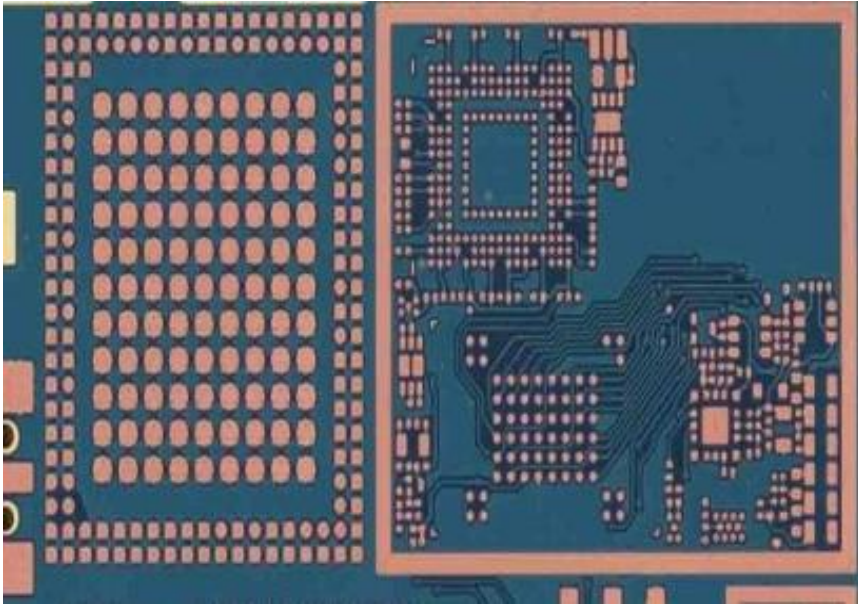
Process, effort, sustainability

Advantages and disadvantages, storage, costs

Known risks in the field

THE MOST IMPORATANT SURFACES IN DETAIL

OSP [Organic Surface Protection]



Description:

An organic coating (usually an azole-based film) that protects the copper surface from oxidation.

Details

- Layer thickness: 0.1 / 0.6 μm
- Storage time: 6 months

Applications

- Soldering
- Press-fit
- Fine -pitch
- BGA

Advantages

- Cheap
- Flat surface
- Refresh possible
- Nickel-free

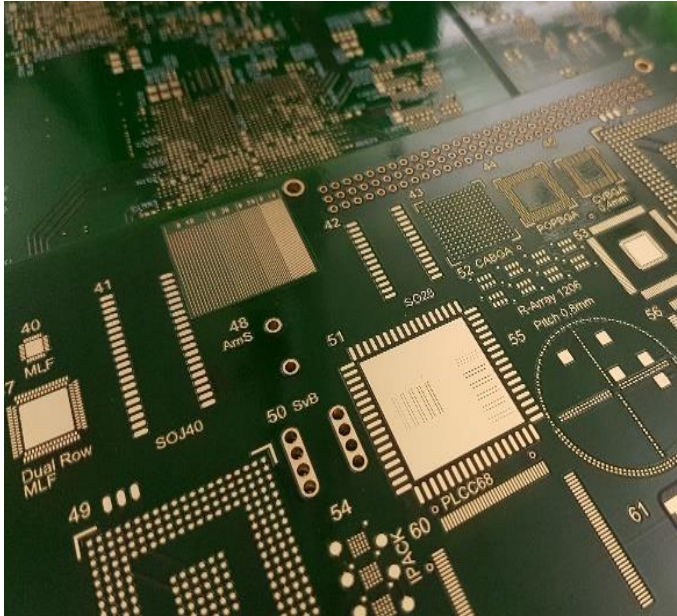
Disadvantages

- Limited number of high temperature processes
- Not bondable

OSP Organic Surface Protection	
0,1 μm / 0,6 μm	Schichtdicken Layer thicknesses
	RoHS Konformität RoHS Compliance
6 Monate 6 months	Lötbarkeit / Lagerfähigkeit Solderability / Shelf life
	Mehrfachlöten Multiple soldering
	Einpresstechnik Press-fit technology
	Fine Pitch Fine pitch
	Leitkleben Conductive adhesive bonding
	Aluminiumdraht Bonden Aluminum wire bonding
	Golddraht Boden Gold wire bonding
	Cu Palladium (PCC) Palladium coated Copper (PCC)
	Kupferdraht Bonden Copper-coated base
	Schadgas SO ₂ SO ₂ -Gas Test
	HF Anwendung HF (High Frequency) application
	Lagerung zwischen Lötprozessen Storage between soldering processes
	Nacharbeit möglich Rework possible
	Steckleisten (PCI) Connectors (PCI)
	Laser-trimmen Laser trimming
	Risiko im Feld Risk in the field
	E-Test auf OF (open faults) Electrical testing on open faults
	Reflow 1-3 x Multiple Soldering (> 3 steps)
	Kosten Cost

THE MOST IMPORATANT SURFACES IN DETAIL

ENIG [Electroless-Nickel-Immersion-Gold]



Description:

A nickel-gold surface in which a thin layer of gold is chemically applied to a nickel base.

Details

- Nickel: 3-6 μm / Gold: 0.05-0.12 μm
- Storage time:: 12 months

Applications

- Soldering
- AL-wire bonding
- Conductive bonding
- Fine Pitch
- BGA

Advantages

- Very planar surface
- Long shelf life
- Versatile in use

Disadvantages

- Expensive
- No refresh possible
- Ni not suitable for high frequency

ENIG Electroless Nickel - Immersion Gold	
3-6 μm Ni + 0,05-0,1 μm Au	Schichtdicken Layer thicknesses
	RoHS Konformität RoHS Compliance
12 Monate 12 months	Lötbarkeit / Lagerfähigkeit Solderability / Shelf life
	Mehrfachlöten Multiple soldering
	Einpresstechnik Press-fit technology
	Fine Pitch Fine pitch
	Leitkleben Conductive adhesive bonding
	Aluminiumdraht Bonden Aluminum wire bonding
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	Cu Palladium (PCC) Palladium coated Copper (PCC)
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	Reflow 1-3 x Multiple Soldering (> 3 steps)
	Kosten Cost

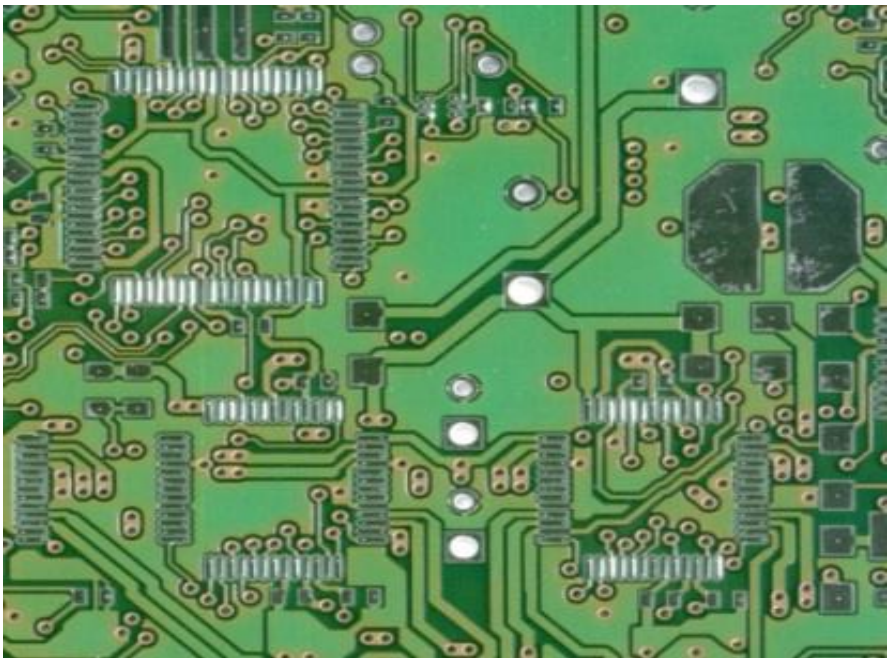
ENIG PROCESS [ELECTROLESS-NICKEL-IMMERSION-GOLD]



Electroless-Nickel-Immersion-Gold-Line [Würth-Elektronik]

THE MOST IMPORATANT SURFACES IN DETAIL

Hot Air Solder Leveling



Description:

A traditional process in which molten lead-free tin (or solder containing lead) is applied to the circuit board. Excess solder is removed with hot air.

Details

- Layer thickness: 1-20 µm
- Storage time:: 12 Monate

Applications

- Soldering
- Press-fit

Advantages

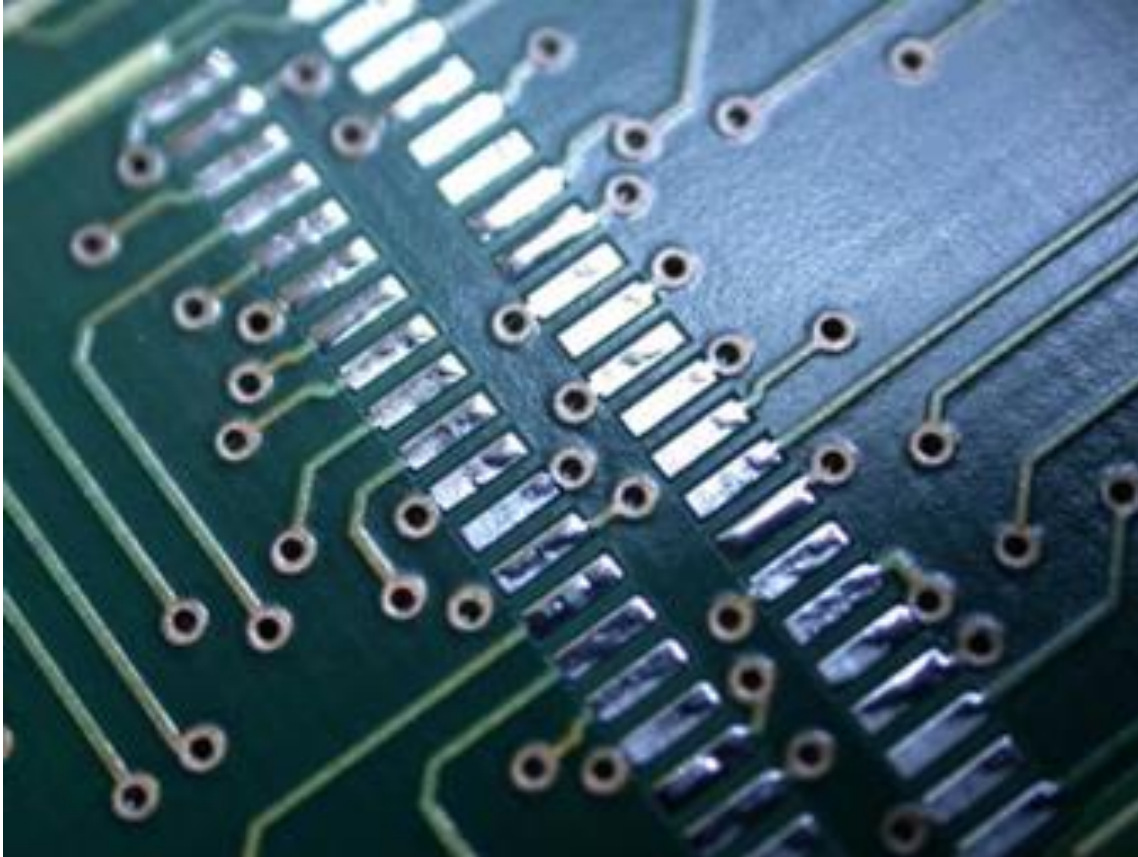
- Proven surface
- Relatively inexpensive
- Long shelf life
- Solder deposit on pads

Disadvantages

- Thermal stress for the material
- Uneven surface
- No fine pitches < 0.25mm
- Cu removal on surface and drill holes
- Not bondable

Hot Air Levelling	
	lead free
1-20 µm	Schichtdicken Layer thicknesses
	RoHS Konformität RoHS Compliance
12 Monate 12 months	Lötbarkeit / Lagerfähigkeit Solderability / Shelf life
	Mehrfachlöten Multiple soldering
	Einpresstechnik Press-fit technology
	Fine Pitch Fine pitch
	Leitkleben Conductive adhesive bonding
	Aluminiumdraht Bonden Aluminum wire bonding
	Golddraht Bonden Gold wire bonding
	Cu Palladium (PCC) Palladium coated Copper (PCC)
	Kupferdraht Bonden Copper-coated base
	Schadgas SO ₂ SO ₂ -Gas Test
	HF Anwendung HF (High Frequency) application
	Lagerung zwischen Lötprozessen Storage between soldering processes
	Nacharbeit möglich Rework possible
	Steckleisten (PCI) Connectors (PCI)
	Laser-trimmen Laser trimming
	Risiko im Feld Risk in the field
	E-Test auf OF (open faults) Electrical testing on open faults
	Reflow 1-3 x Multiple Soldering (> 3 steps)
	Kosten Cost

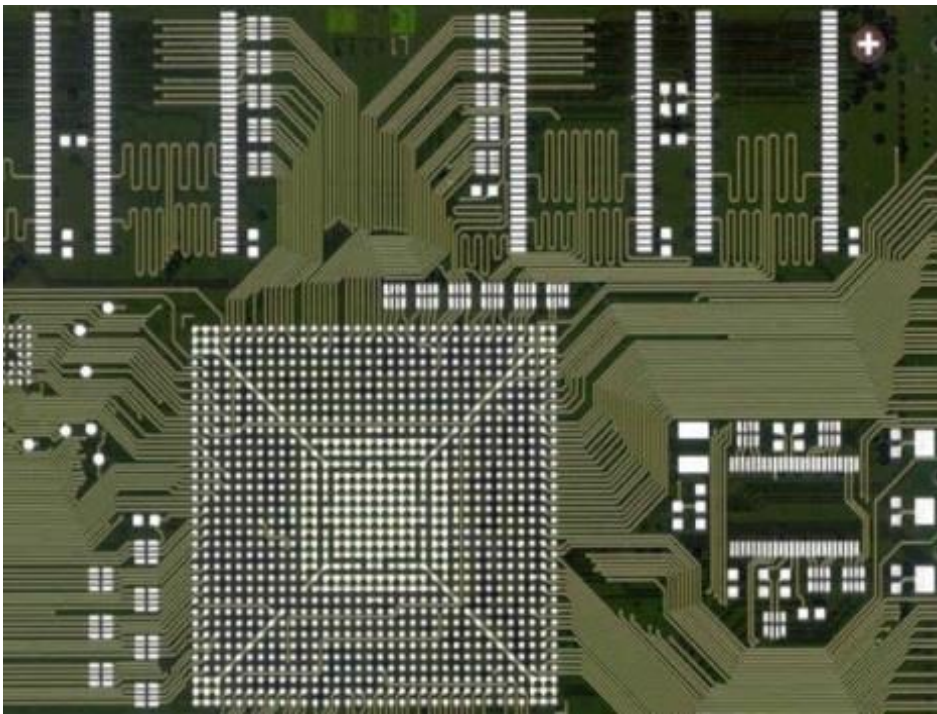
HOT AIR SOLDER LEVELING PROCESS



Hot Air Leveling-Line [Fa. Brautmeier Salzkotten]

THE MOST IMPORATANT SURFACES IN DETAIL

Immersion Tin



Description:

A thin tin layer is chemically deposited directly onto copper in a charge exchange process.

Details

- Layer thickness: 1 µm
- Storage time:: 6 months

Applications

- Soldering
- Press-fit
- Fine Pitch
- BGA

Advantages

- Planar surface
- Refresh possible

Disadvantages

- Limited number of high temperature processes
- Not bondable

Immersion Tin	
1 µm	Schichtdicken <i>Layer thicknesses</i>
	RoHS Konformität <i>RoHS Compliance</i>
6 Monate 6 months	Lötbarkeit / Lagerfähigkeit <i>Solderability / Shelf life</i>
	Mehrfachlöten <i>Multiple soldering</i>
	Einpresstechnik <i>Press-fit technology</i>
	Fine Pitch <i>Fine pitch</i>
	Leitleben <i>Conductive adhesive bonding</i>
	Aluminiumdraht Bonden <i>Aluminum wire bonding</i>
	Golddraht Boden <i>Gold wire bonding</i>
	Cu Palladium (PCC) <i>Palladium coated Copper (PCC)</i>
	Kupferdraht Bonden <i>Copper-coated base</i>
	Schadgas SO ₂ <i>SO₂ -Gas Test</i>
	HF Anwendung <i>HF (High Frequency) application</i>
	Lagerung zwischen Lötprozessen <i>Storage between soldering processes</i>
	Nacharbeit möglich <i>Rework possible</i>
	Steckleisten (PCI) <i>Connectors (PCI)</i>
	Laser-trimmen <i>Laser trimming</i>
	Risiko im Feld <i>Risk in the field</i>
	E-Test auf OF (open faults) <i>Electrical testing on open faults</i>
	Reflow 1-3 x <i>Multiple Soldering (> 3 steps)</i>
	Kosten <i>Cost</i>

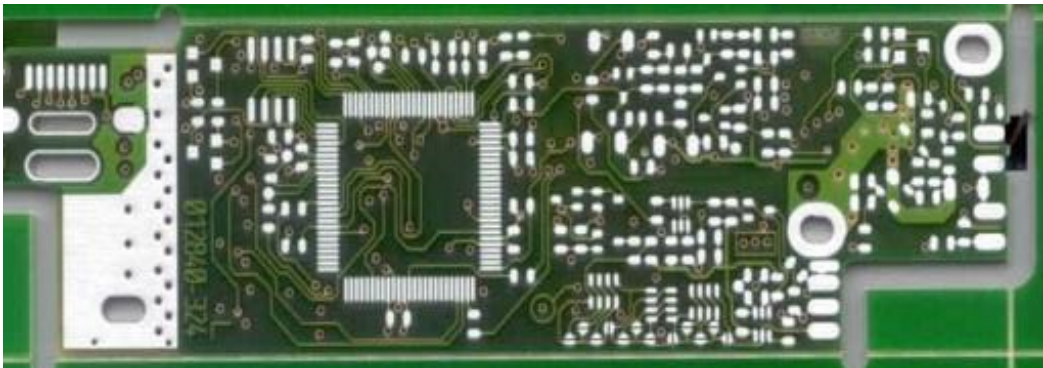
IMMERSION TIN PROCESS



Immersion Tin Hofstetter

THE MOST IMPORTANT SURFACES IN DETAIL

Immersion Silver



Description:

The silver layer is chemically deposited directly onto copper in a charge exchange process.

Details

- Layer thickness: 0.12 / 0.3 µm
- Storage time:: 12 months***

Applications

- Soldering
- Press-fit
- Fine Pitch
- BGA

Advantages

- Affordable
- Flat surface
- Nickel-free

Disadvantages

- Storage (***)Special packaging)
- Not suitable for all end applications - Sulphide-free application site

Immersion Silver	
0,12 - 0,3 µm	Schichtdicken Layer thicknesses
	RoHS Konformität RoHS Compliance
12 Monate 12 months	Lötbarkeit / Lagerfähigkeit Solderability / Shelf life
	Mehrfachlöten Multiple soldering
	Einpresstechnik Press-fit technology
	Fine Pitch Fine pitch
	Leitleben Conductive adhesive bonding
neigt zur Korrosion prone to corrosion	Aluminiumdraht Bonden Aluminum wire bonding
	Golddraht Boden Gold wire bonding
	Cu Palladium (PCC) Palladium coated Copper (PCC)
	Kupferdraht Bonden Copper-coated base
	Schadgas SO ₂ SO ₂ -Gas Test
	HF Anwendung HF (High Frequency) application
	Lagerung zwischen Lötprozessen Storage between soldering processes
	Nacharbeit möglich Rework possible
	Steckleisten (PCI) Connectors (PCI)
	Laser-trimmen Laser trimming
	Risiko im Feld Risk in the field
	E-Test auf OF (open faults) Electrical testing on open faults
	Reflow 1-3 x Multiple Soldering (> 3 steps)
	Kosten Cost

THE MOST IMPORTANT SURFACES IN DETAIL

	OSP <i>Organic Surface Protection</i>	Hot Air Levelling <i>lead free</i>	Hot Air Levelling <i>lead</i>	Immersion Tin	Immersion Silver	ENIG <i>Electroless Nickel - Immersion Gold</i>	ENEPIG <i>Electroless Nickel -Electroless Palladium -Immersion Gold</i>	Electroplated Softgold	Electroplated Hardgold
Schichtdicken <i>Layer thicknesses</i>	0,1 µm /0,6 µm	1-20 µm	1-20 µm	1 µm	0,12 - 0,3 µm	3-6 µm Ni + 0,05-0,1 µm Au	3-8 µm Ni + 0.05-0.15 µm Pd 0.05-0.1 µm Au	4-6 µm Ni + > 1.0 µm Au	4-6 µm Ni + 0.8 - 2.0 µm Au
RoHS Konformität <i>RoHS Compliance</i>									
Lötbarkeit / Lagerfähigkeit <i>Solderability / Shelf life</i>	6 Monate 6 months	12 Monate 12 months	12 Monate 12 months	6 Monate 6 months	12 Monate 12 months	12 Monate 12 months	12 Monate 12 months	12 Monate 12 months	12 Monate 12 months
Mehrfachlöten <i>Multiple soldering</i>									
Einpresstechnik <i>Press-fit technology</i>									
Fine Pitch <i>Fine pitch</i>									
Leitkleben <i>Conductive adhesive bonding</i>									
Aluminiumdraht Bonden <i>Aluminum wire bonding</i>					neigt zur Korrosion prone to corrosion			Zuverlässigkeitsprobleme reliability issues	
Golddraht Boden <i>Gold wire bonding</i>									
Cu Palladium (PCC) <i>Palladium coated Copper (PCC)</i>									
Kupferdraht Bonden <i>Copper-coated base</i>									
Schadgas SO ₂ <i>SO2 -Gas Test</i>									
HF Anwendung <i>HF (High Frequency) application</i>									
Lagerung zwischen Lötprozessen <i>Storage between soldering processes</i>									
Nacharbeit möglich <i>Rework possible</i>									
Steckleisten (PCI) <i>Connectors (PCI)</i>									
Reflow 1-3 x <i>Multiple Soldering (> 3 steps)</i>									
Kosten <i>Cost</i>									



SELECTION CRITERIA

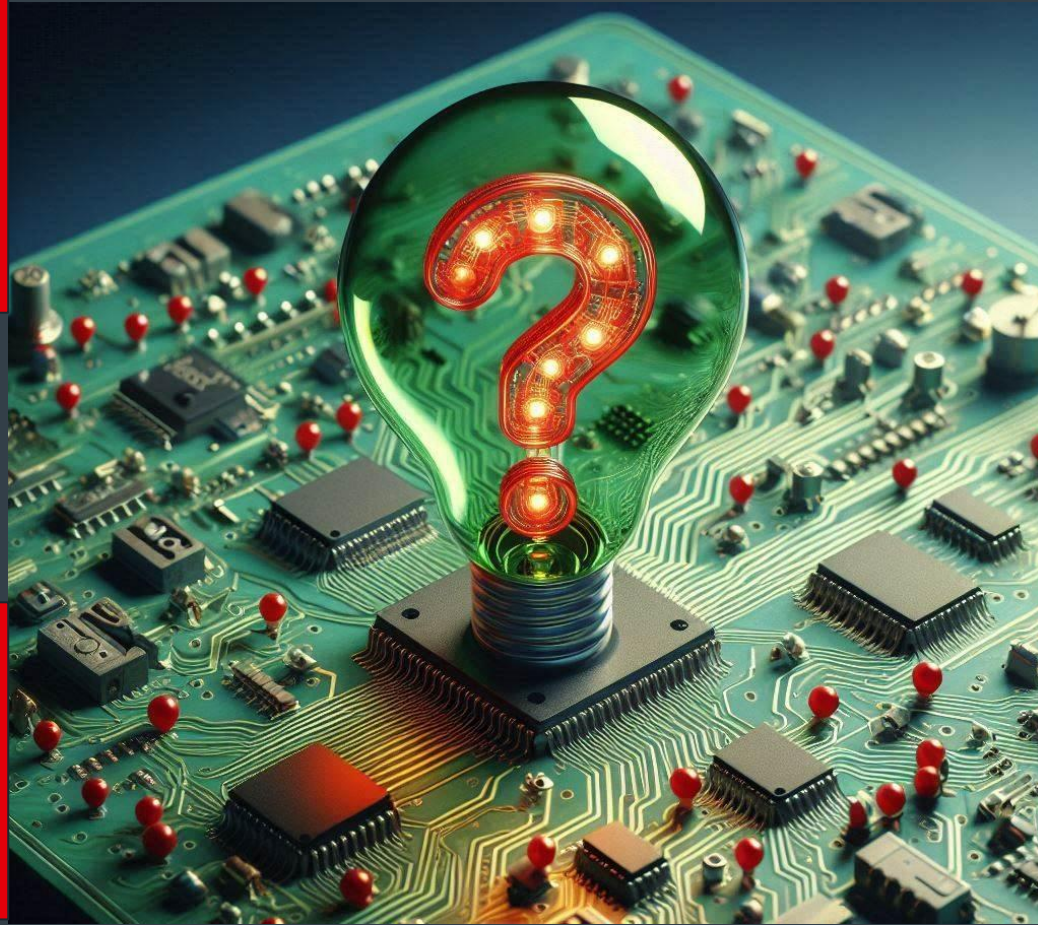
SELECTION CRITERIA

Process

- Costs
- Environmental compatibility

Functionality

- Layout
- Components



Reliability

- Thermal resistance
- Long-term stability
- Shelf life

Joinability

- Soldering
- Wire bonding
- Bonding
- Press-fit

DEFINITION OF THE REQUIREMENTS FOR THE SOLDER SURFACE

High frequency / High speed

Environmental conditions in the field

Contact surfaces [PCI,ZIF ect.]

Mechanical requirements

Surface requirement [planarity]

Press-fit technology

Fine-pitch components

Application area [noxious gas]

Wire-bonding / conductive bonding

Number of soldering processes

Cost factors

Disposal costs

Storage between soldering processes

Storage time [unsoldered / soldered] [u

Environmental requirements

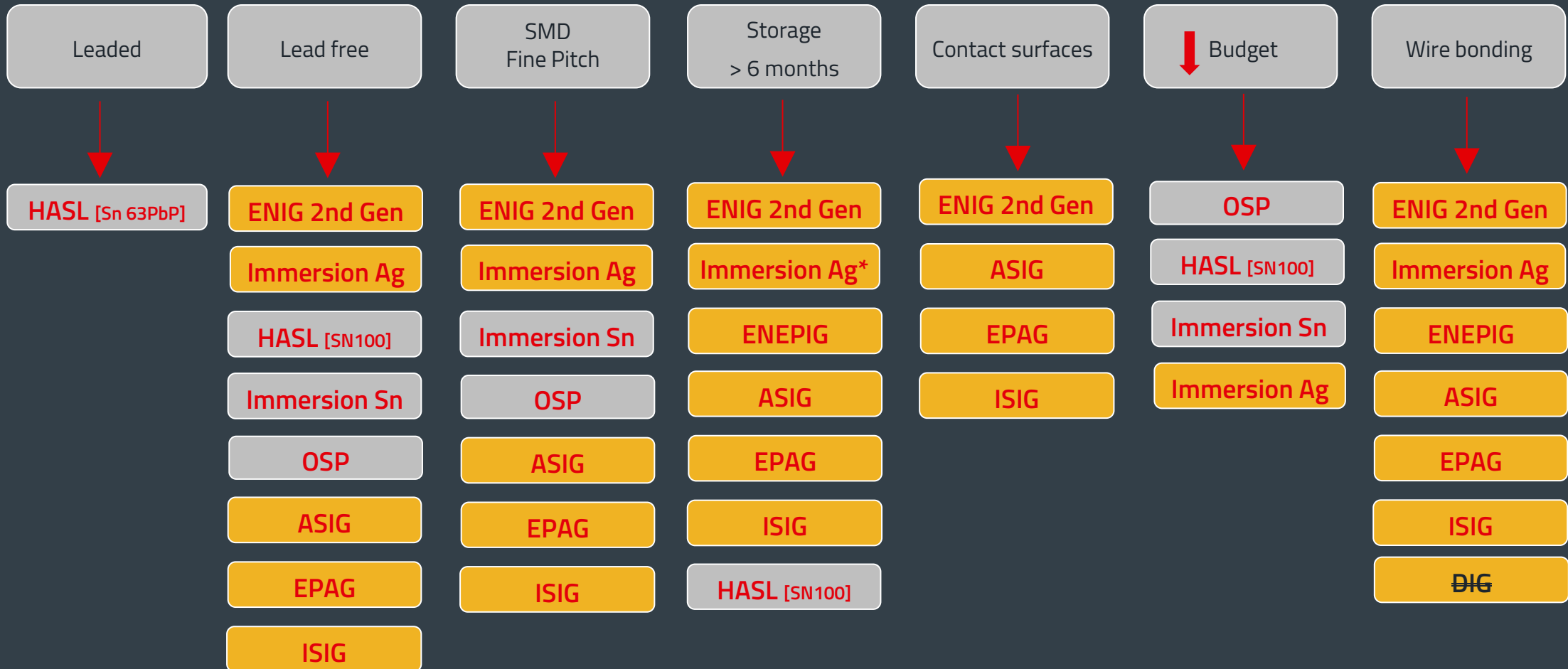
Drying process [ageing]

Via-plugging [vacuum]

Nickel-free

QUICK SELECT

bondable surface



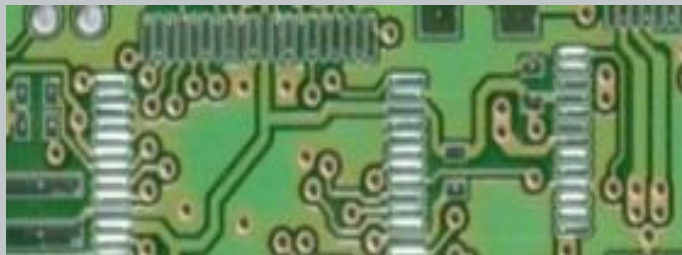
KNOWN RISKS IN THE FIELD

KNOWN RISKS IN THE FIELD

Global situation

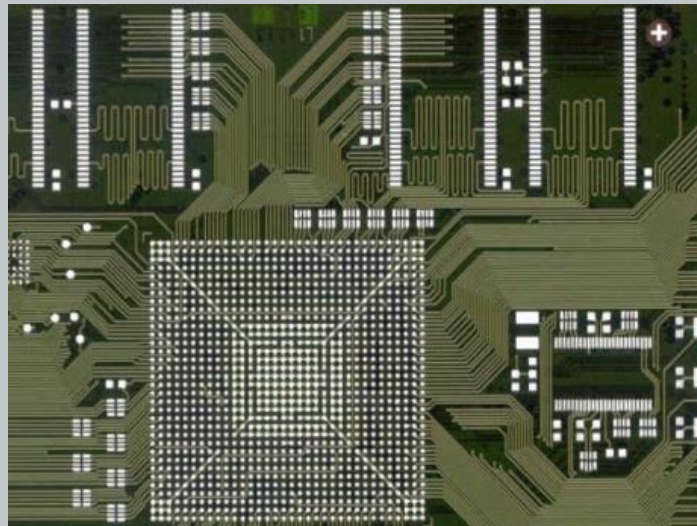
HASL (lead free)

- Yellow effect
- Wetting problems
- Layer thickness variation
- Soldering problems due to yellow effect
- Layer thickness too high
- Tin piles – short circuits
- Small pads in the ground areas not wetted



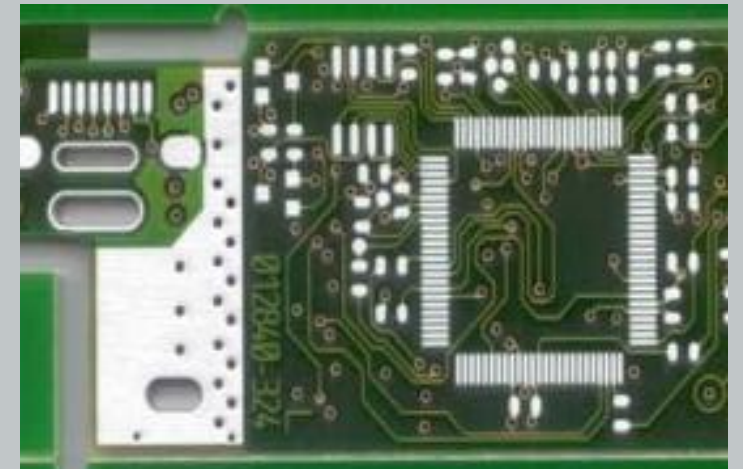
Immersion Tin

- Whisker formation
- Undercut (Interruptions)
- Mousbites
- Storage



Immersion Ag

- Creep corrosion
- Oxidation
- Storage

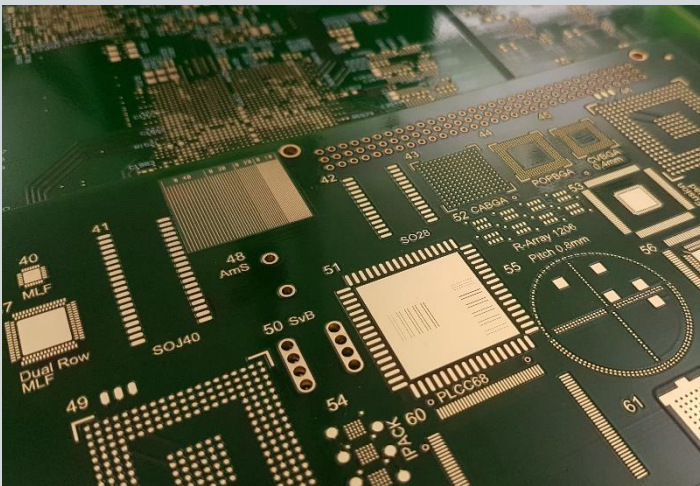


KNOWN RISKS IN THE FIELD

Global situation

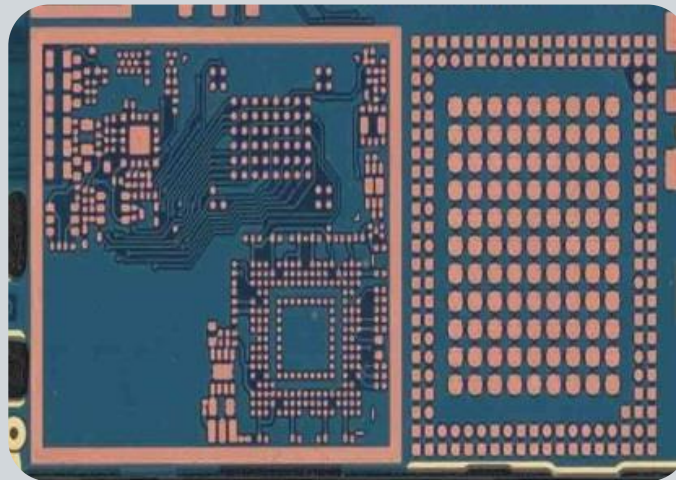
ENIG - Ni- Pd/Au

- Black Pad
- Bad wire bonding performance
- Soldering problems
- Ink bleeding = missing pad
- Black Pad / Nickel corrosion



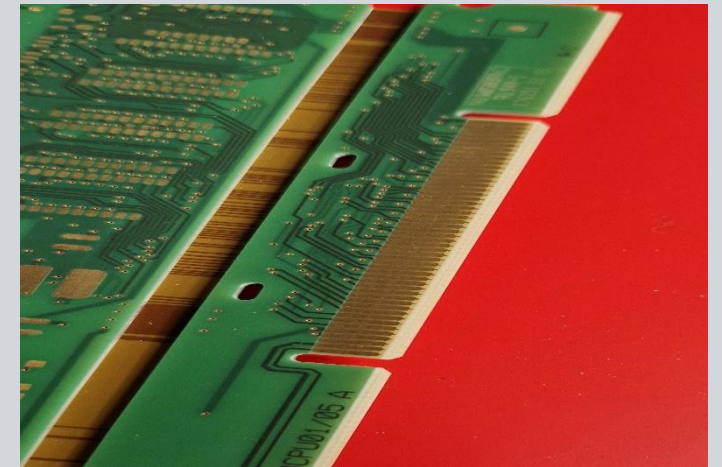
OSP

- Soldering problems, wetting
- Multiple solderings
- Mechanical damage
- Oxidation



Hard gold / soft gold

- Soldering problems, diffusion problems
- Mechanical damage
- Oxidation
- Abrasion resistance



WHAT DOES SOLDERING MEAN FOR THE PCB?

HOW DOES A DRYING PROCESS AFFECT
THE SOLDER SURFACE?

WHAT DOES SOLDERING MEAN FOR THE PCB?

Thermo-mechanical stress

Why stress

- All materials expand differently and act on each other (shear stresses)
- Moisture weakens adhesion at interfaces or wants to escape
- Microstructure changes

Recommendation

- Dry storage and, if necessary, sufficient drying before soldering (mandatory for flexible and rigid-flex PCBs)
- Sensitive monitor temperature profiles in the soldering process
- Monitor storage times / climate
- Optimize logistics

STRESS

WHAT DOES SOLDERING MEAN FOR THE PCB?



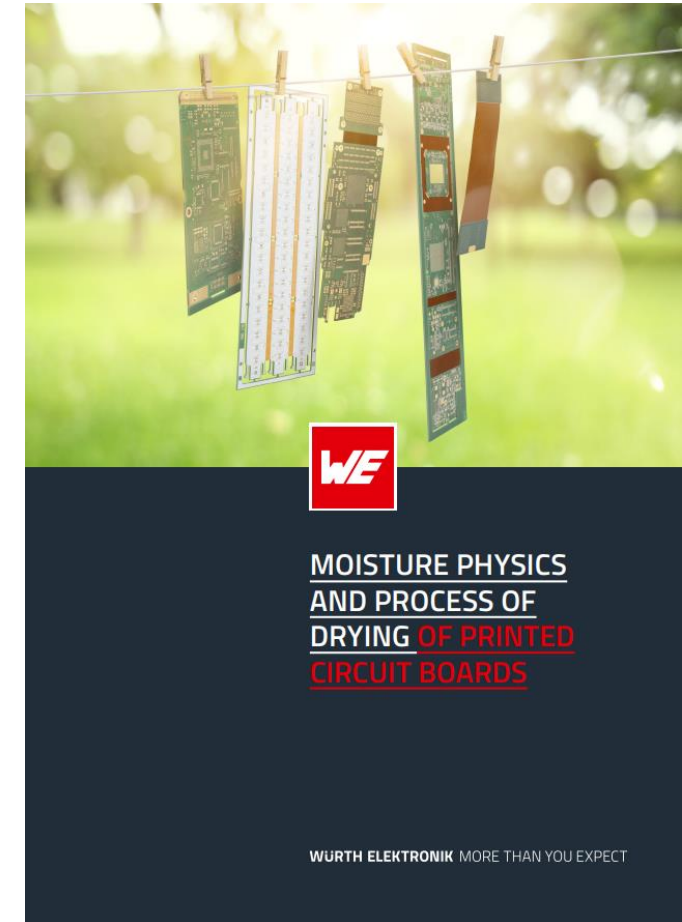
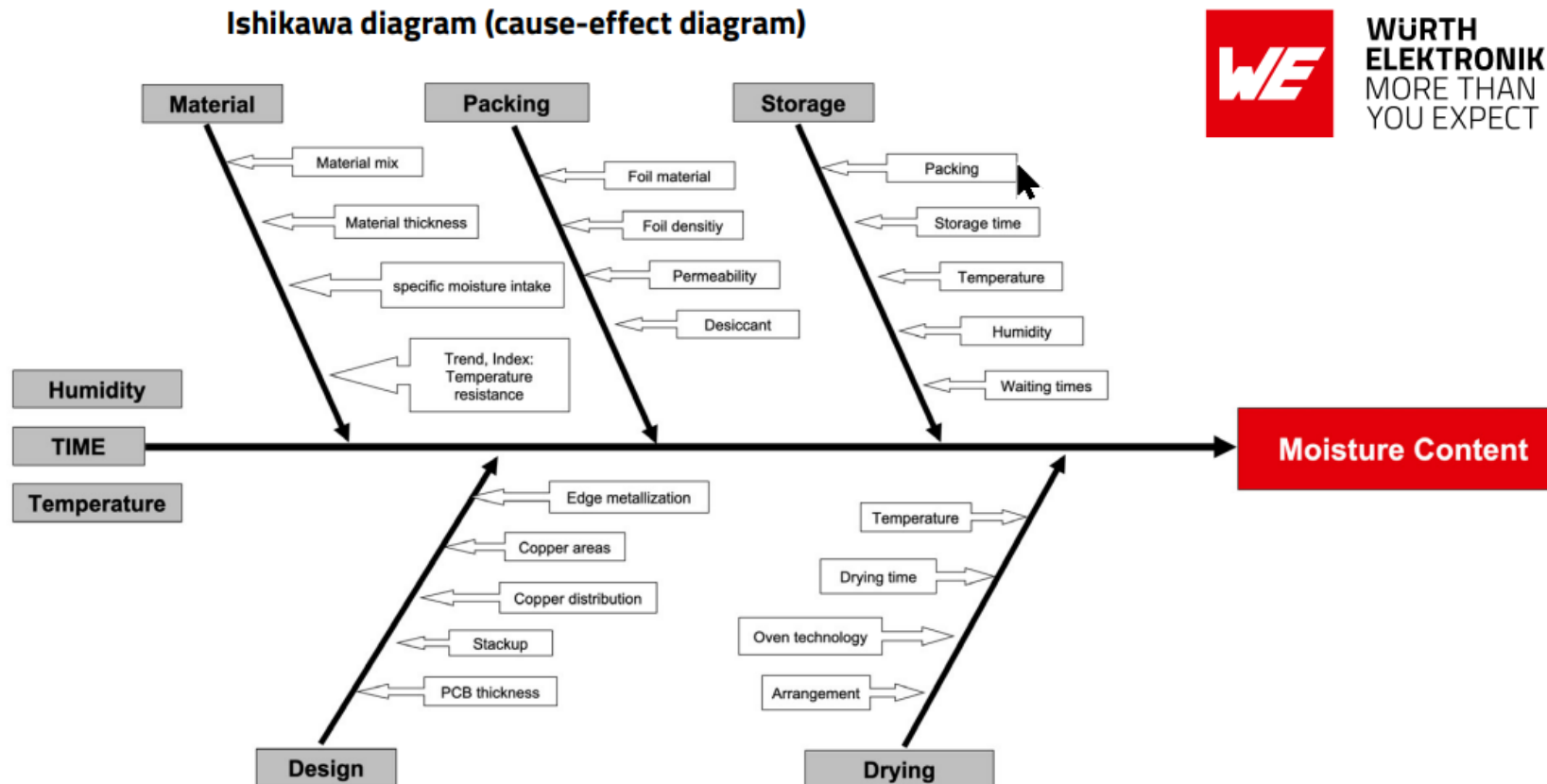
<https://www.we-online.com/dryingprocess>

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WHAT DOES SOLDERING MEAN FOR THE PCB?

The amount of moisture absorbed depends on many factors



INTERMEDIATE STORAGE

RECOMMENDATION “INTERIM STORAGE” WITH INTERCEPT ®

- **Positive:**

- **Protects** iron, non-ferrous metals, alloys, plastics, and some organic materials.
- **Free of outgassing** (awarded the German Hazardous Substance Protection Award in 2005 in the category of alternative solutions for conventional corrosion protection).
- Flexible protection duration (2 to 15 years), reusable up to 5 years.
- No need for oils and degreasing, clean and simple application.
- Cost-effective (total cost consideration).
- Less packaging material needed, increases shipping volume.
- Proven and tested corrosion protection from **-35°C to +80°C**.
- Already proven by many applications and **ISO 9001:2015** certified.
- Recyclable, reusable.
- Technology can be incorporated into existing materials (trays, boxes), up to 5 years circulation possible.

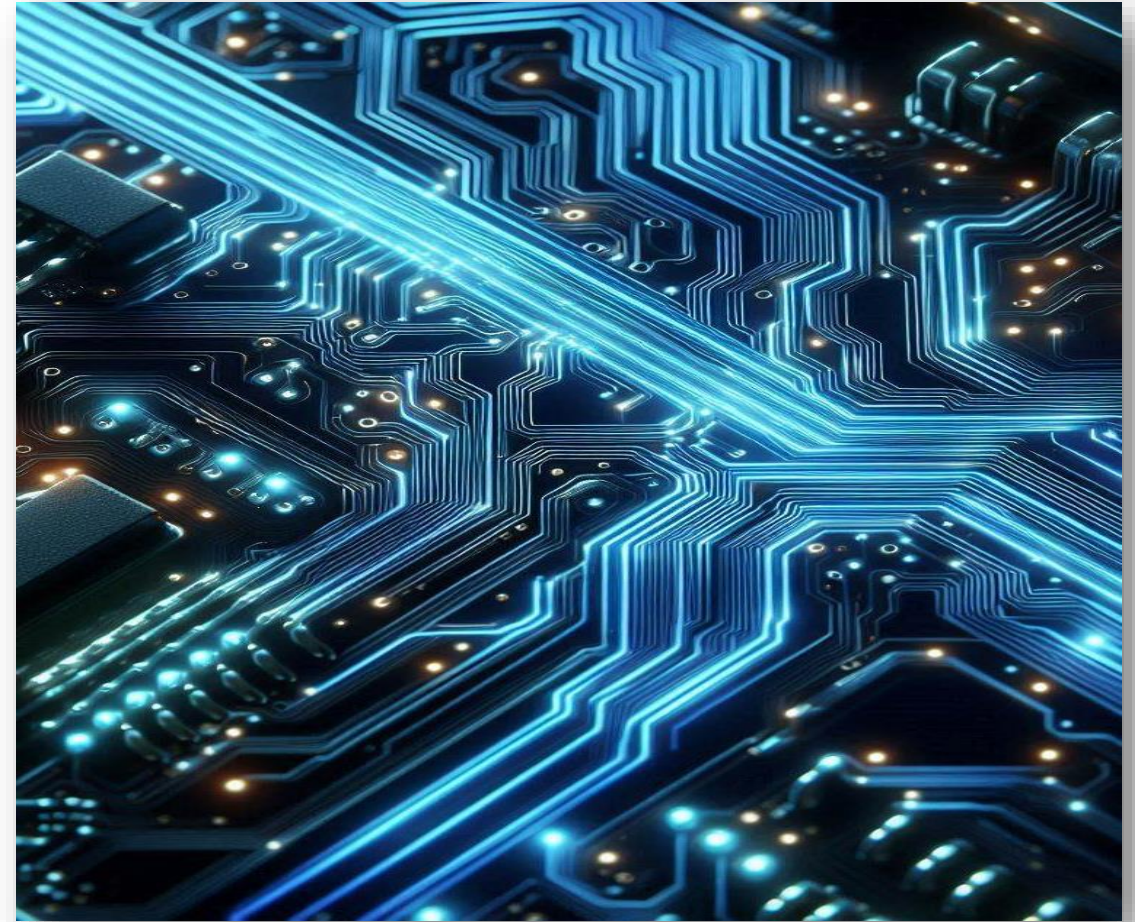
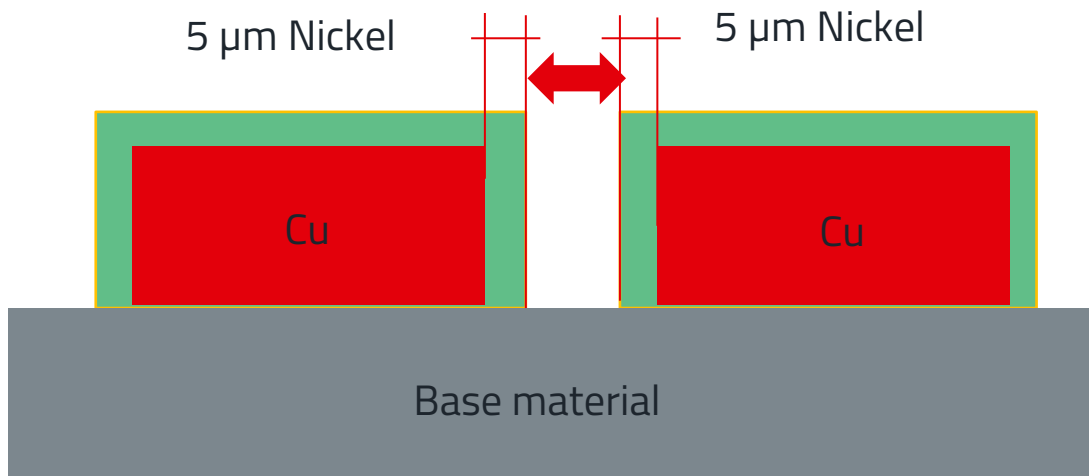
- **Negative:** Higher initial costs.



CHALLENGES OF THE FUTURE

CHALLENGES OF THE FUTURE

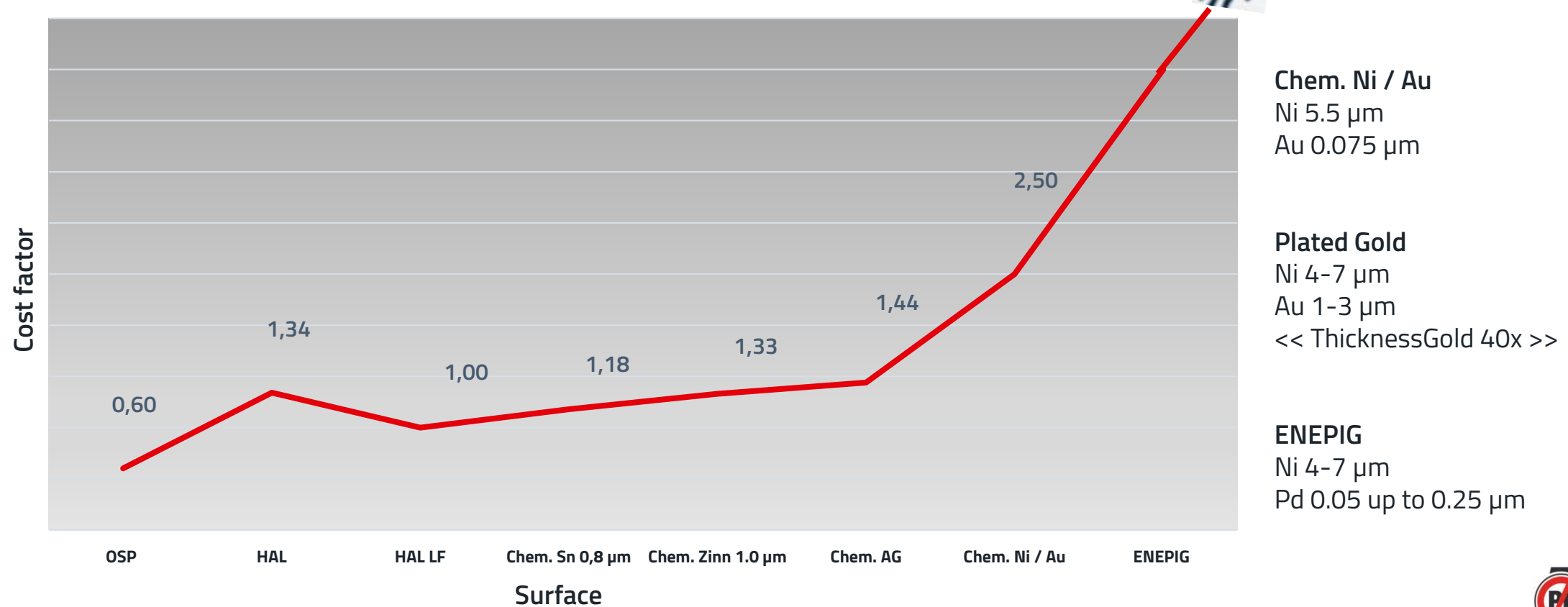
Visualization of an ENIG surface



LEAD-FREE PRINTED CIRCUIT BOARD SURFACES - COST OVERVIEW

Material prices of various end surfaces

- Effect of the material price on the PCB price



LEAD-FREE PRINTED CIRCUIT BOARD SURFACES - COST OVERVIEW

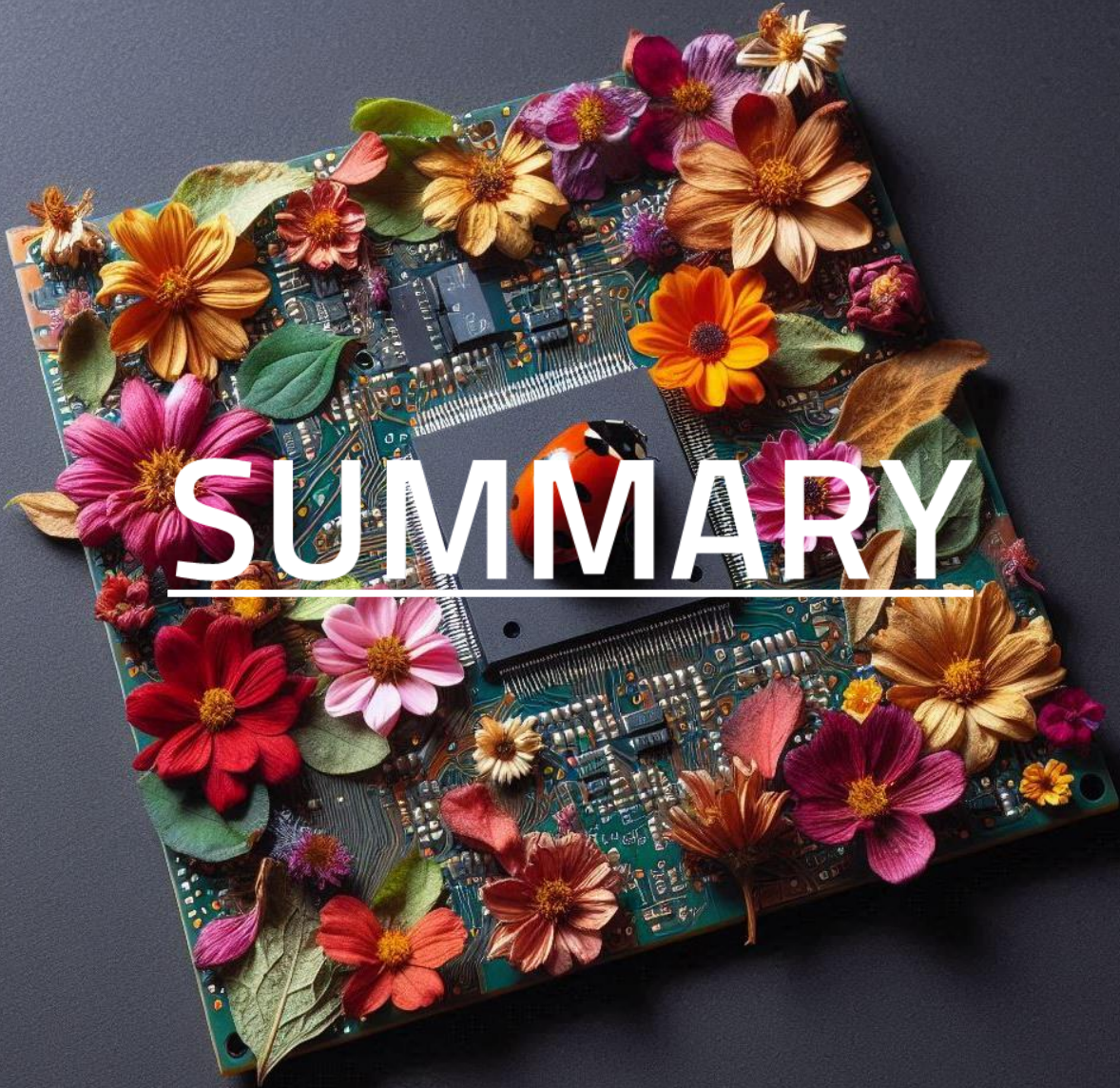
Gold



- Gold price development in dollars over the last 5 years



Source: Finanzen.net



SUMMARY

It is expected that in the coming years, more environmentally friendly and energy-efficient methods for coating printed circuit boards and similar products will gain importance.

- Stricter environmental regulations
- Increased material efficiency
- Greater use of eco-friendly coatings
- Circular economy and recycling