

A Summary of Methods for Minimizing Tin Whisker Growth

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Outline of Presentation



- Whisker Test Matrix
- Theory regarding Critical angles
- Additional tests carried out
- Results
- Conclusions
- Recommendations

Whisker Test Matrix



- Matte 90/10 Sn/Pb
- Matte pure tin (4 types)
- Matte Sn/Cu (5 types)
- Matte Sn/Ag (3 types)
- Matte Sn/Bi (3 types)
- Bright pure tin (3 types)
- Bright 90/10 Sn/Pb
- Bright Sn/Cu (2 types)

Whisker Test Matrix



- Olin 194 substrate
- Alloy 42 substrate
- Brass substrate
- Nickel undercoat
- Copper undercoat
- 3 and 10 microns deposit thickness
- Annealing 150°C, 1 hour

Conclusions



- No drop-in replacement for 90/10 Sn/Pb exists
- Use of a nickel barrier layer reduces whiskering
- Deposit annealing reduces whiskering
- Small amounts of alloying elements are insufficient to prevent whiskering
- Thicker coatings are helpful in reducing whiskering

Conclusions



- Bright tin processes were shown to be low whiskering, lead-free solutions for connector applications
- A whisker test of 52°C and 98%RH for 3 months is a good discriminatory test
- Development of a truly whisker free tin process is still a goal

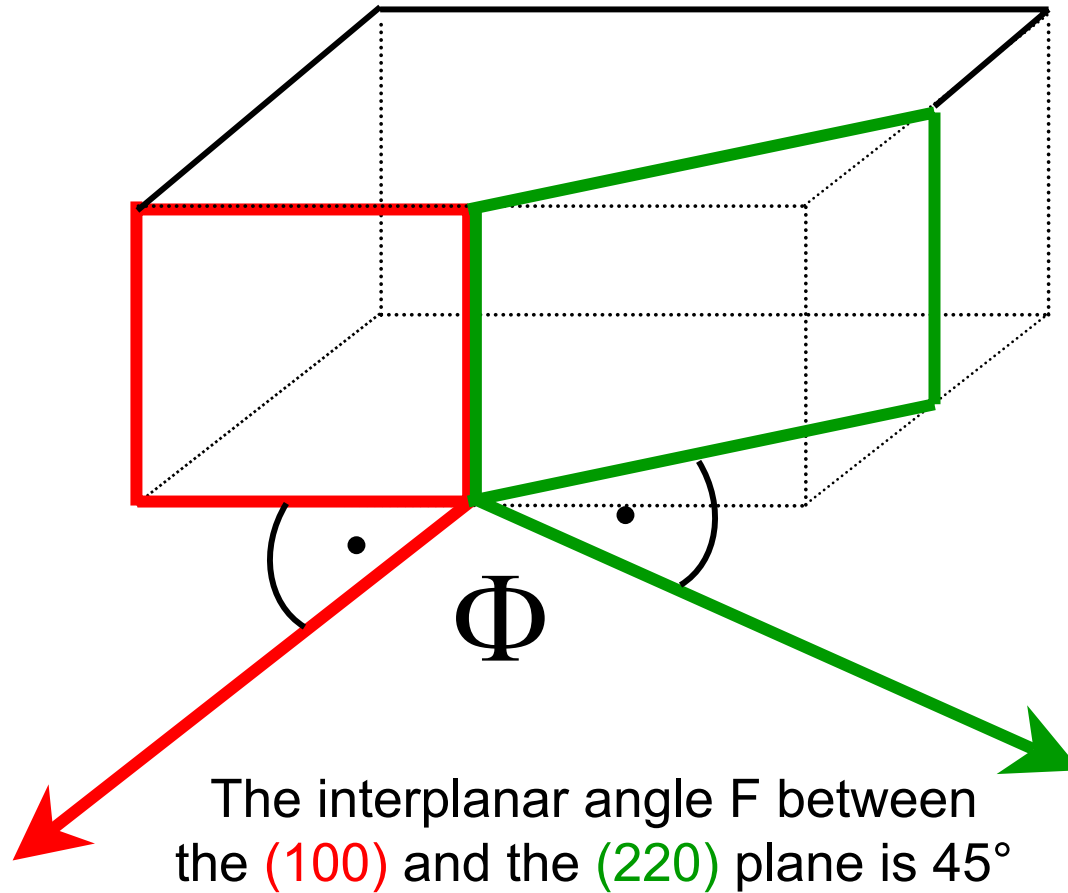
Influence of Crystal Orientation

New theory on the influence and ***interaction*** of the individual crystal orientations on ***one another*** is the basis of our current work.

Hypothesis:

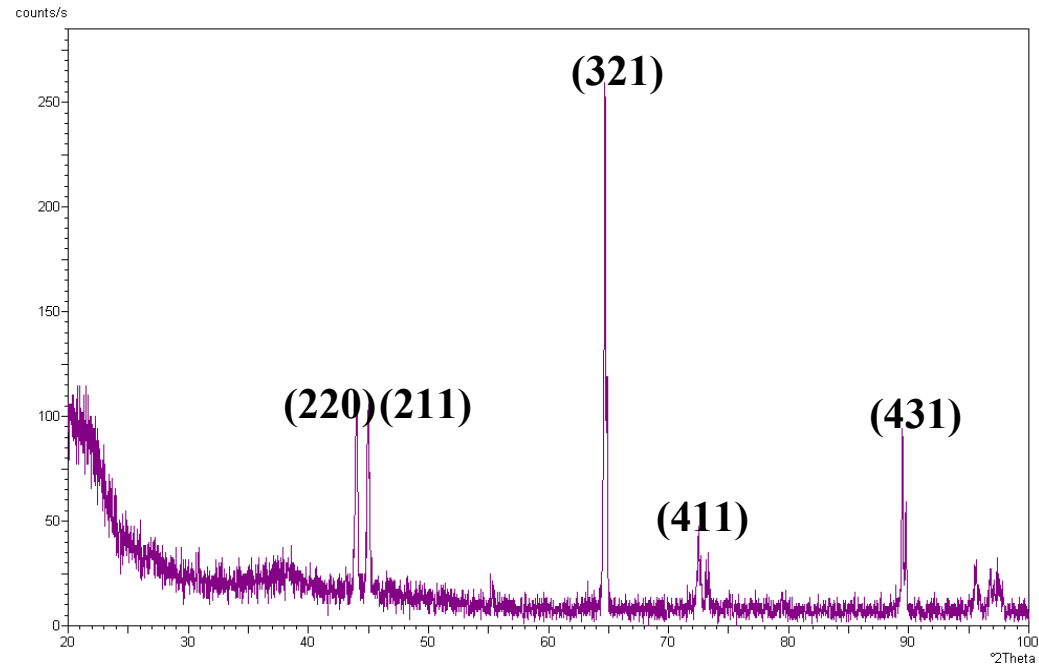
The smaller the angle between two crystal planes, the higher the risk of whisker growth.

Angle Between Two Crystal Planes



XRD of Matte, High Whiskering Tin

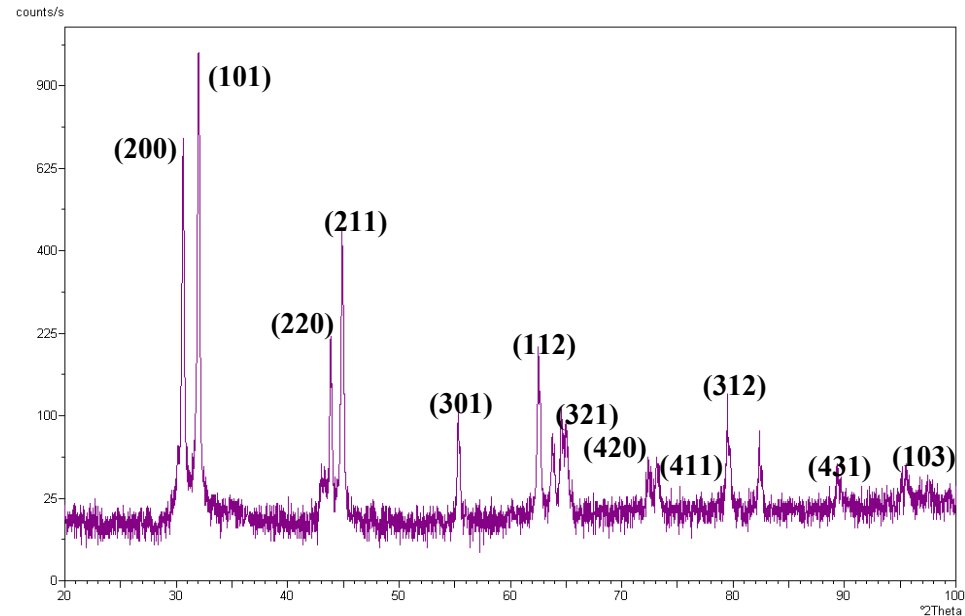
220	211	321	431	
90°	42.8°	29.6°	21.8	220
	28.3°	13.7°	21.6°	211
		20.1°	7.41°	321
			15.3°	431



⇒ High whisker risk

XRD of Bright, **Low** Whiskering Tin

200	101	220	211	
90°	61.4°	45°	46.2°	200
	40°	70.2°	27.4°	101
		90°	42.8°	220
			28.3°	211



↓

Larger angles: Very low whisker risk

Critical Angle Conclusion



Observation:

Angles between crystal planes in the range of **5 - 22°** are considered critical, and where whisker growth will be most susceptible.

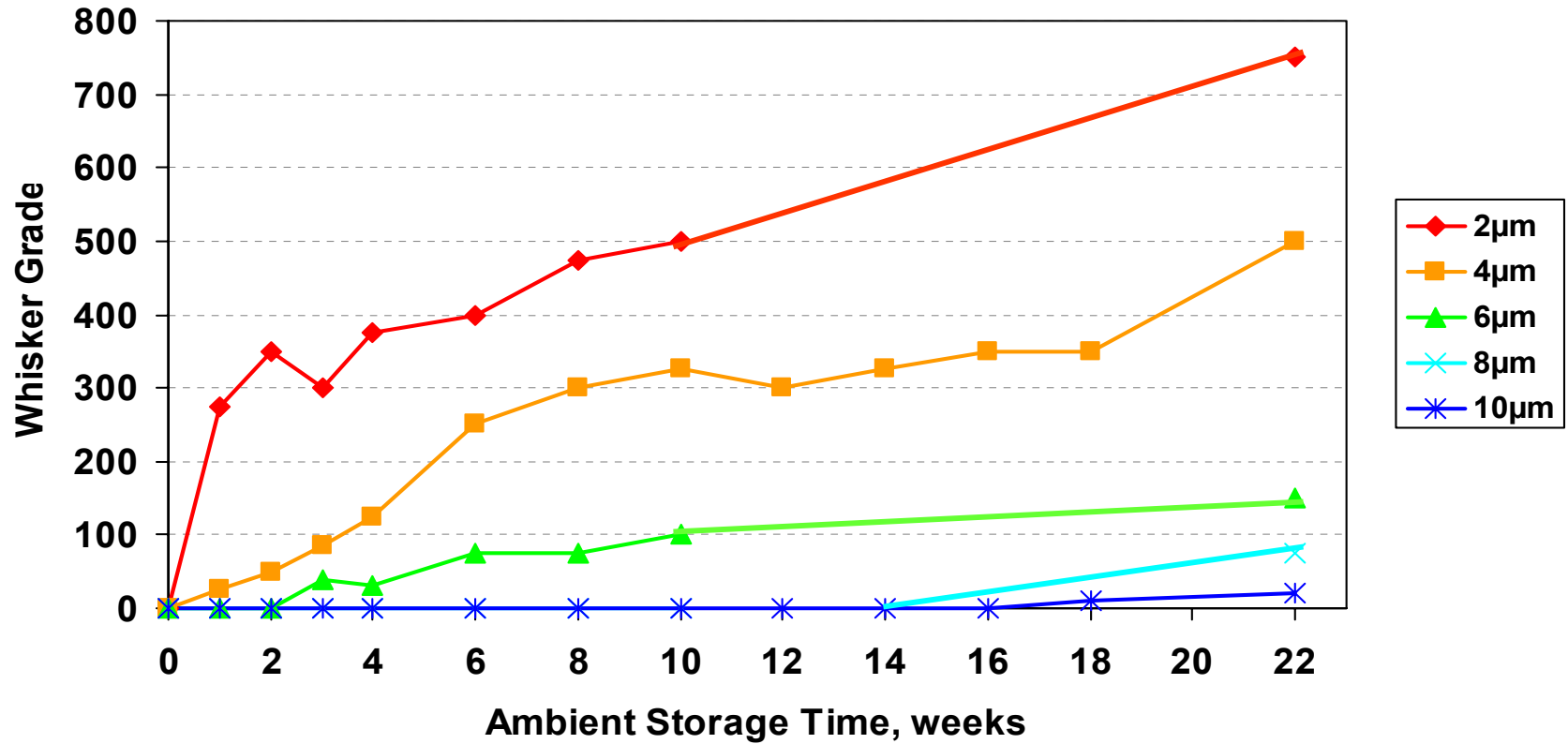
Additional Parameters Studied



- Deposit thickness
- Undercoats (copper & nickel)
- Annealing

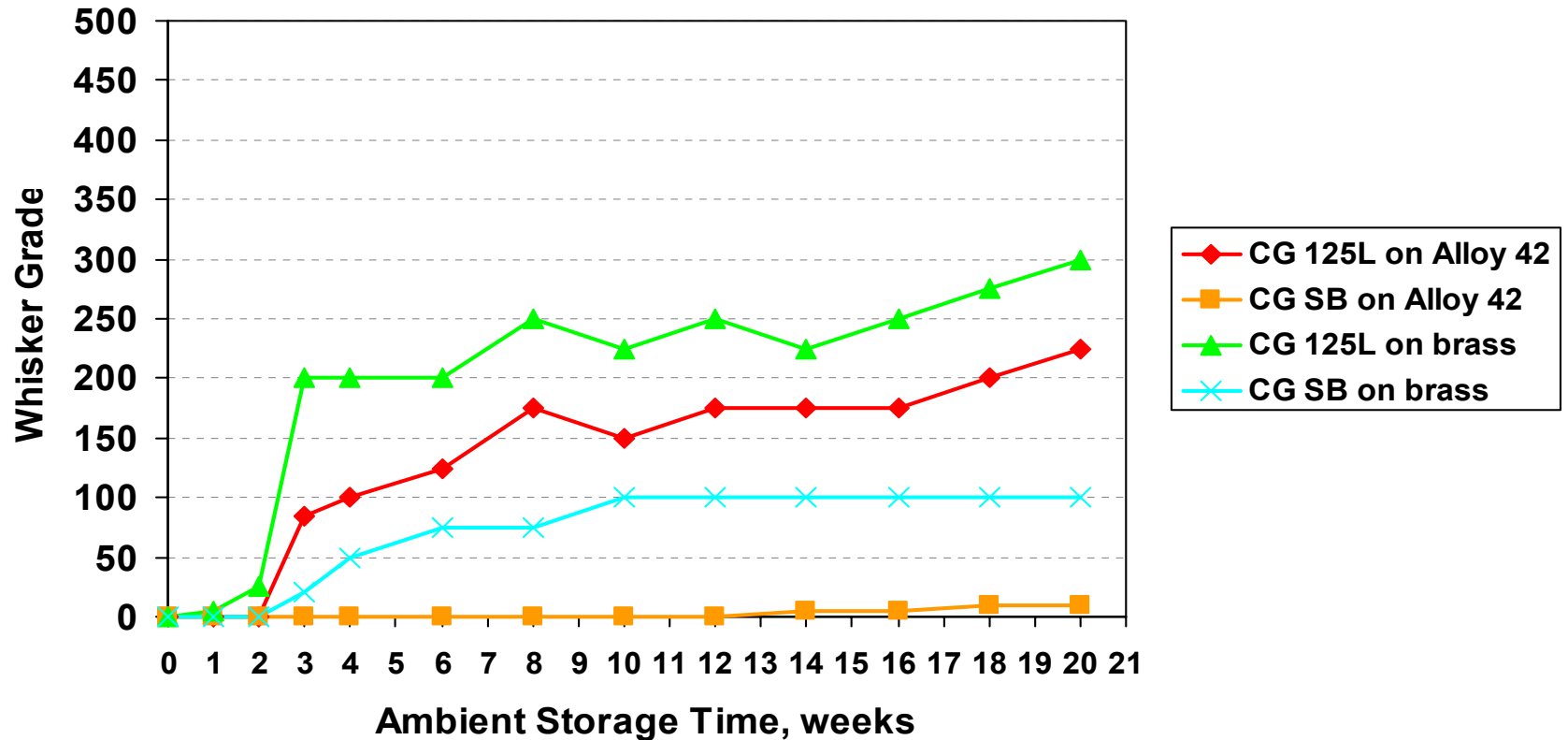
Whiskering vs Deposit Thickness

Olin 194 stamped lead frame



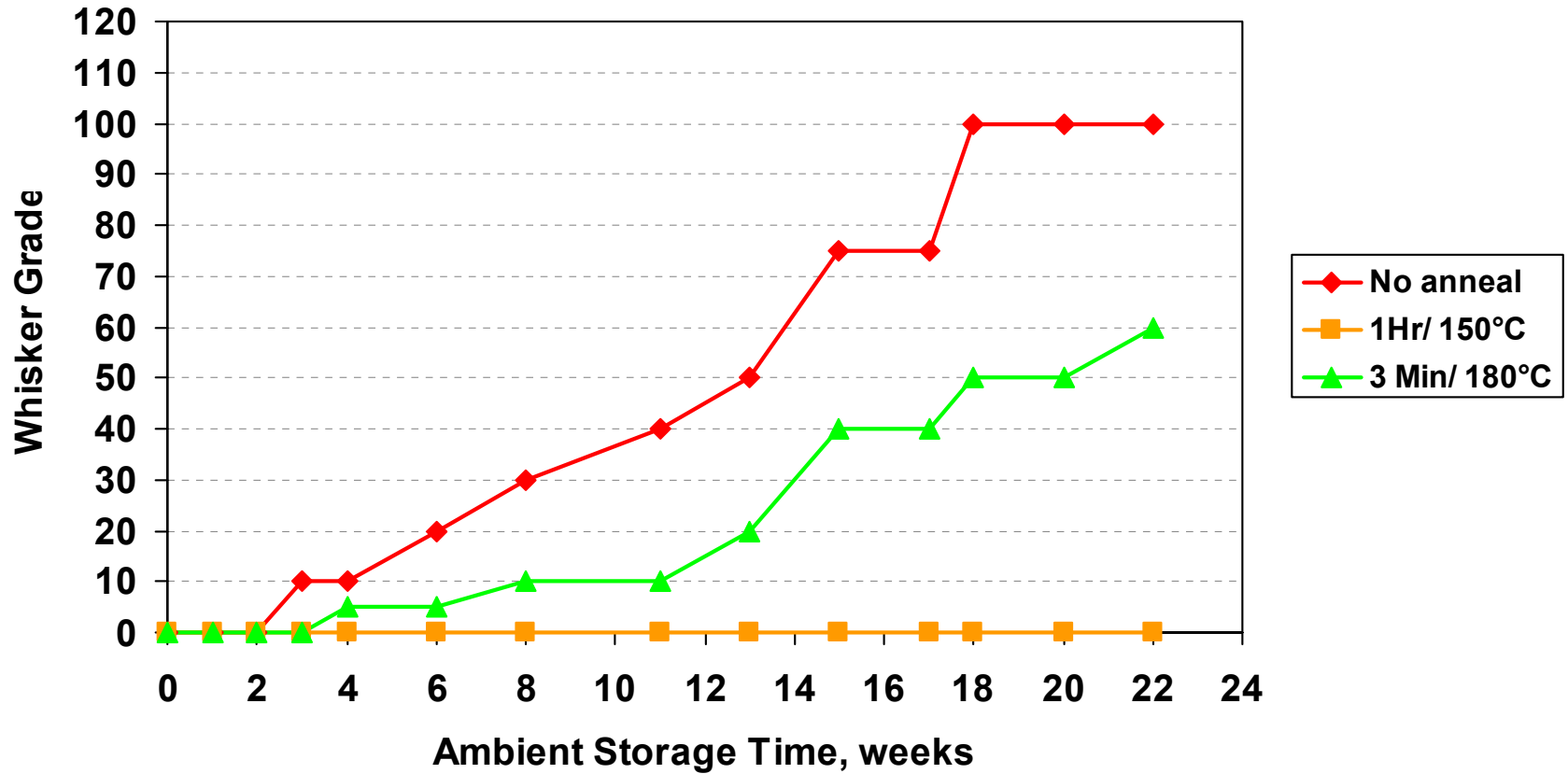
Whiskering on Copper Undercoats

Etched lead frames, 5 μ m copper undercoats, 3 μ m tin deposits



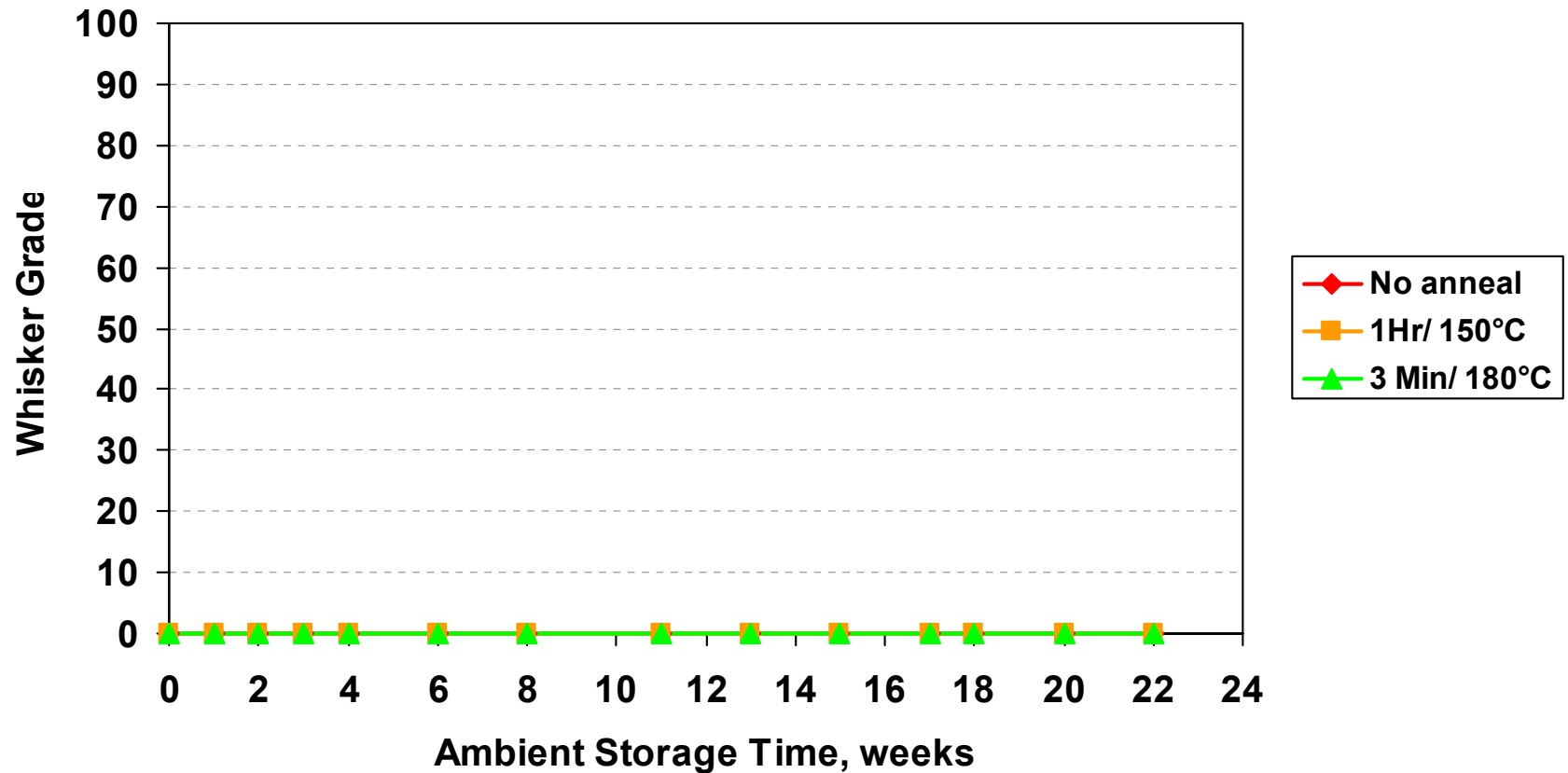
Effects of Annealing

Etched Olin 194 lead frames, 3 μ m tin deposit, no nickel undercoat



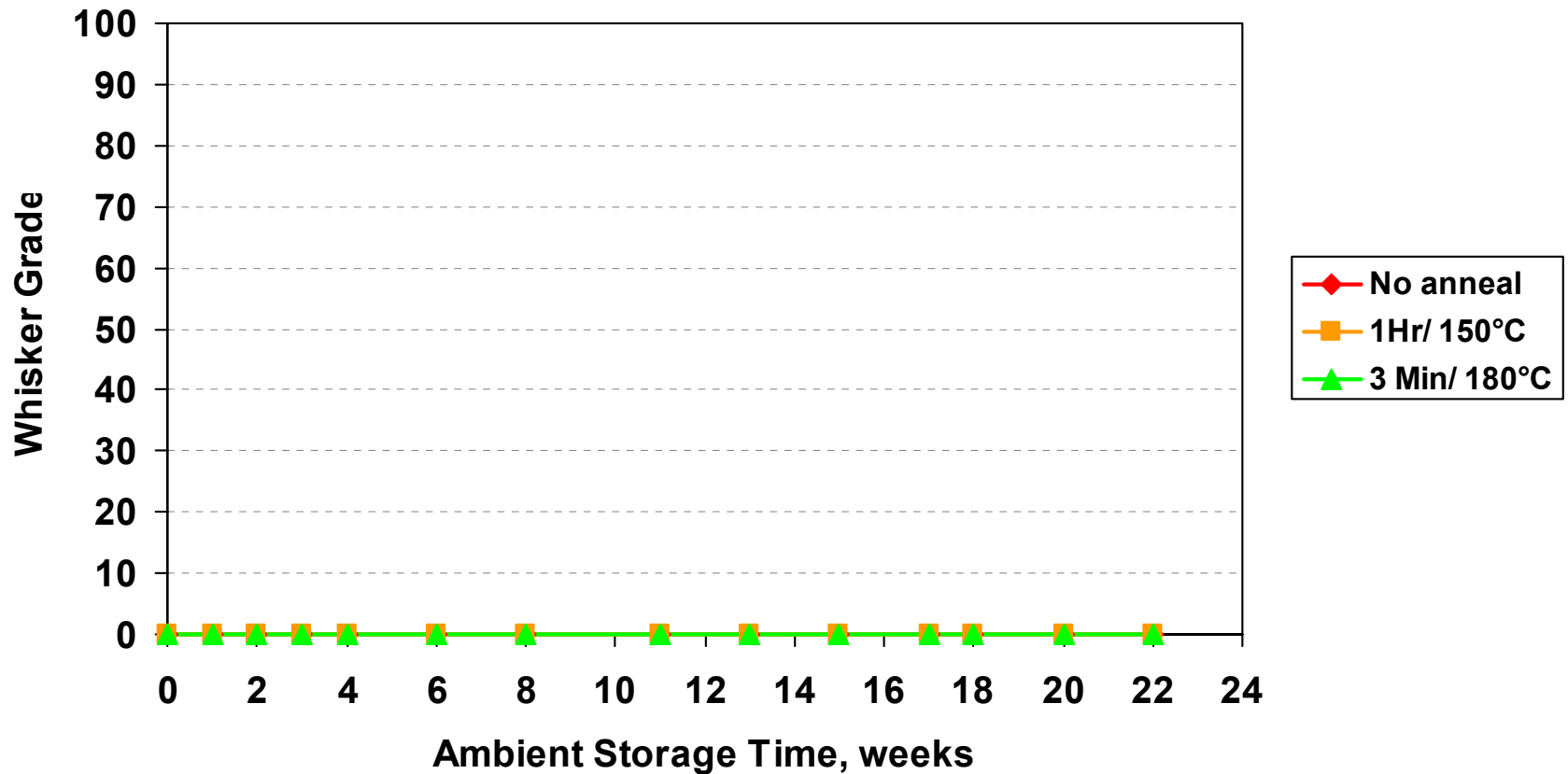
Effects of Nickel Undercoat and of Annealing

Etched Olin 194 lead frames, 3 μ m tin deposit, 2 μ m nickel undercoat



Effects of Nickel Undercoat and of Annealing

Etched Olin 194 lead frames, 3 μ m tin deposit, 0.5 μ m nickel undercoat



Conclusions



- The use of a nickel underlayer (0.5 μm) is effective in preventing whisker formation
- The use of post-plate annealing (one hour at 150°C) is also effective in preventing whisker growth
- When using copper undercoats, the type of process used is critical to success

Recommendations



- A tin coating thickness of $>10\ \mu\text{m}$ is recommended to minimize whisker risk
- A copper or nickel barrier layer can be used to prevent whiskering
- A deposit annealing procedure should be used if the use of an undercoat is not practicable