

GD - Goal is to find a thin coating that could be applied to pure Sn plating that would 1) prevent whiskers and 2) not significantly degrade solderability.

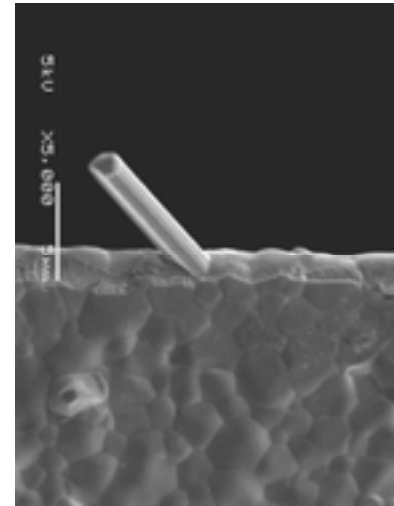
Prevention of Sn whisker formation by surface treatment of Sn plating Part II

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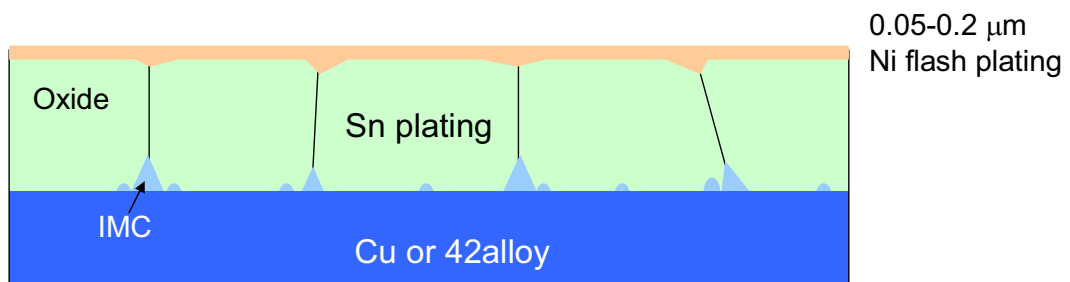
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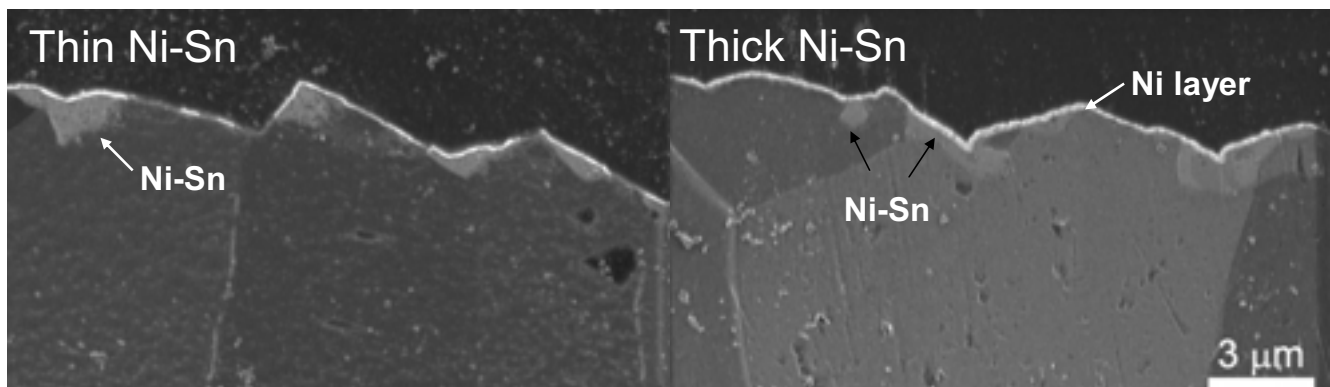


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Surface treatment on Sn plating



Schematic illustration of Sn plating

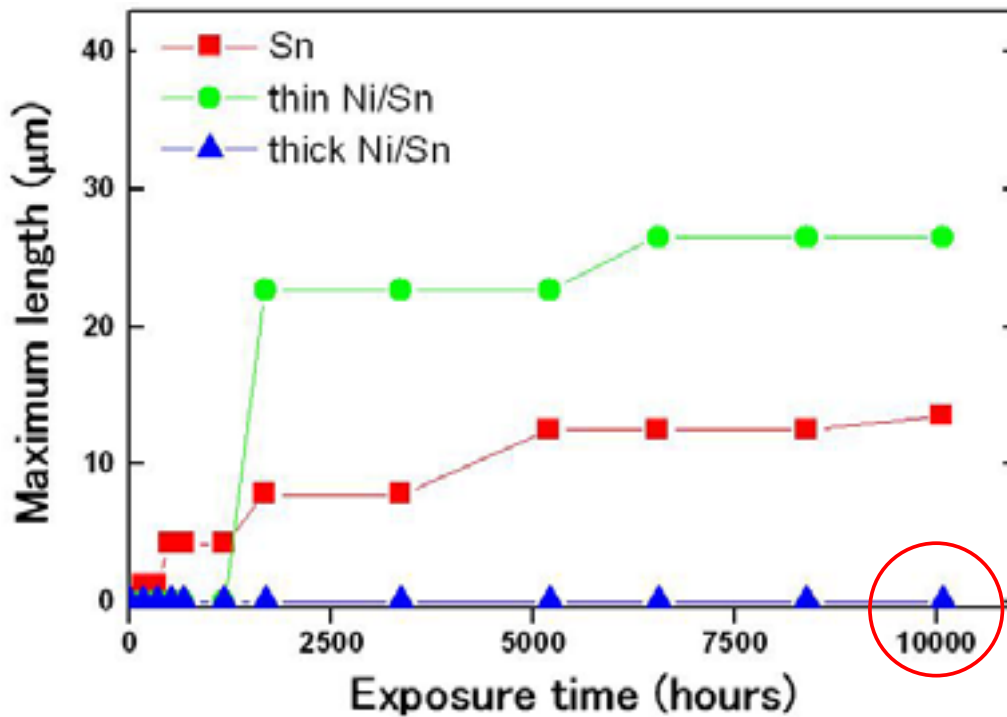


“Thin (0.05μm)” Ni plating forms discontinuous Ni nano particles islands on Sn surface

“Thick (0.2 μm)” Ni plating covers Sn surface

GD - Ni on Sn forms islands (thin) or layers (thick), plus local IMC regions, presumably growing from nucleation sites.

Changes in whisker maximum length

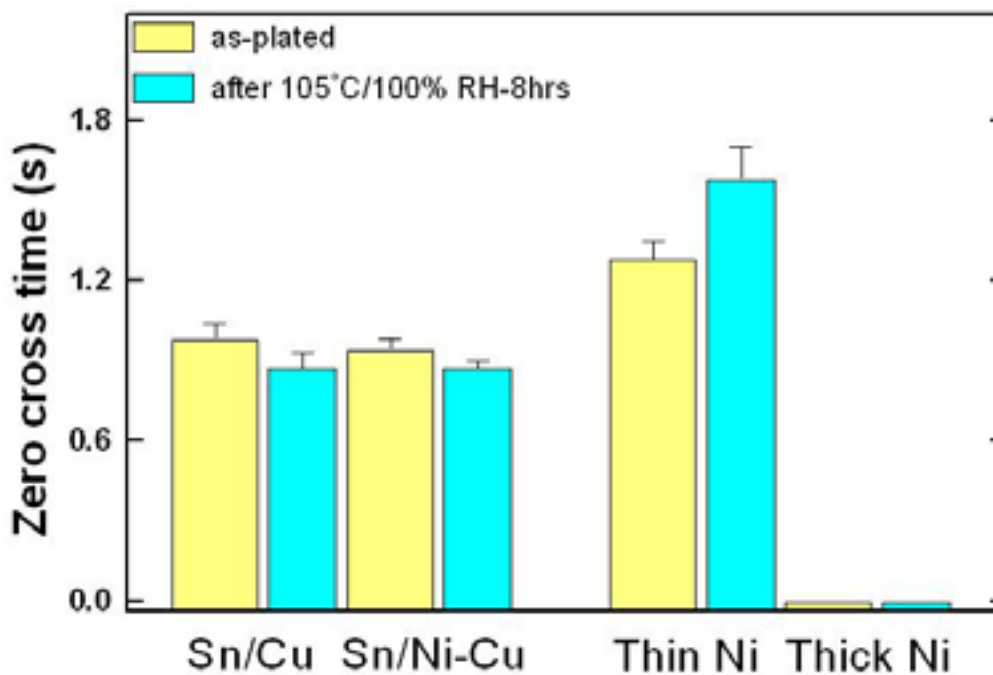


✓ No whisker is formed on thick Ni/Sn plating

GD - Thin Ni seems to promote whisker growth (local compressive stresses?), but thick Ni completely suppresses whisker growth for at least 10,000 hrs (see slide 7 showing > 20,000 hrs) while uncoated and presumably similar specimens develop whiskers in < 1000 hrs.

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Wetting behavior of various surface treatment samples



✓ Wetting of thin Ni plating is equivalent to Sn plating while that of thick Ni is worse.

GD - Wetting balance zero-cross times shown as zero are actually infinite. Thick Ni destroyed solderability and was not further investigated.

Experimental details

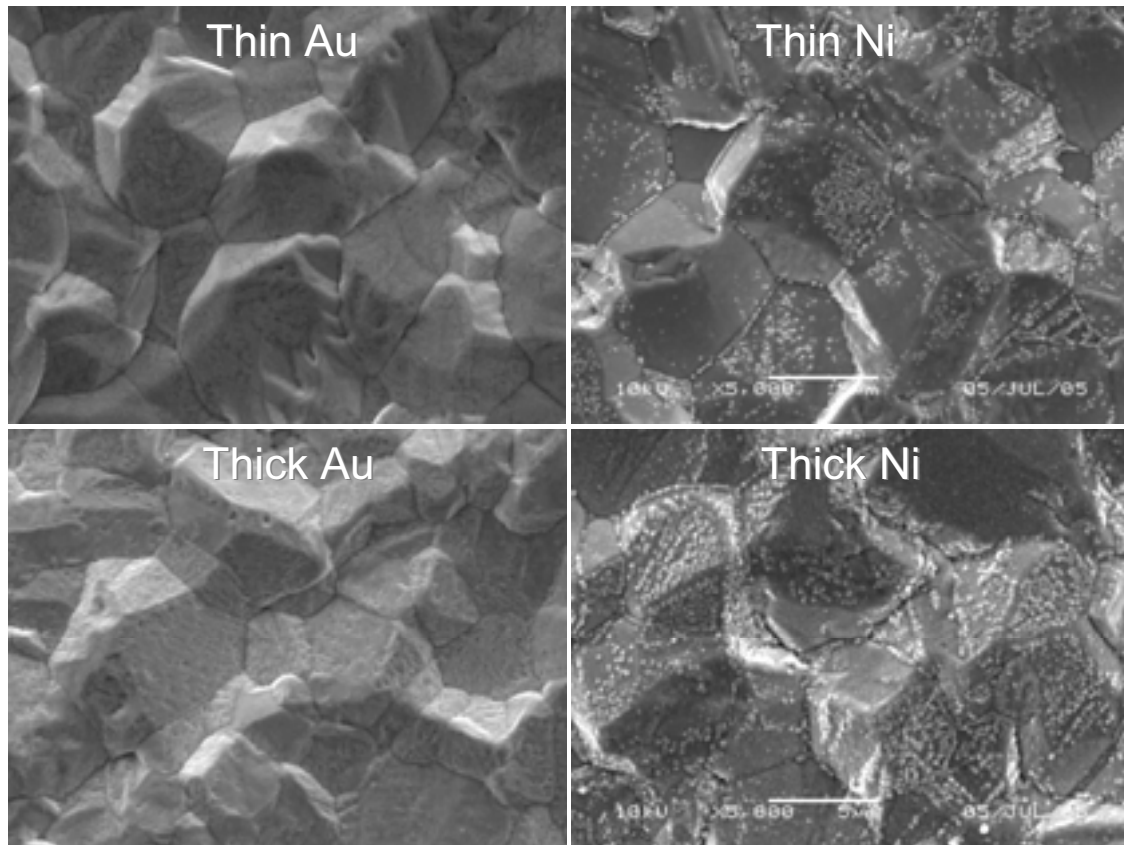
- Materials : 1) pure Sn plating
(t:6 μ m, current density: 5A/dm² - 5.5min)
2) thin (0.05 μ m) Au or Pd/Sn plating
3) thick (0.2 μ m) Au or Pd/Sn plating
- Electrode : Cu, 42alloy
- Exposure at room temperature over 8000 hrs
- Microstructure observation: TEM, SEM, XRD
- Static indentation loading test (load:300g,)
- Wetting test

GD - Specimens with pure Sn plating were the controls. Purpose was to see if a thin or thick coating of Au or Pd/Sn, presumably electrodeposited, would inhibit whisker growth yet preserve solderability.

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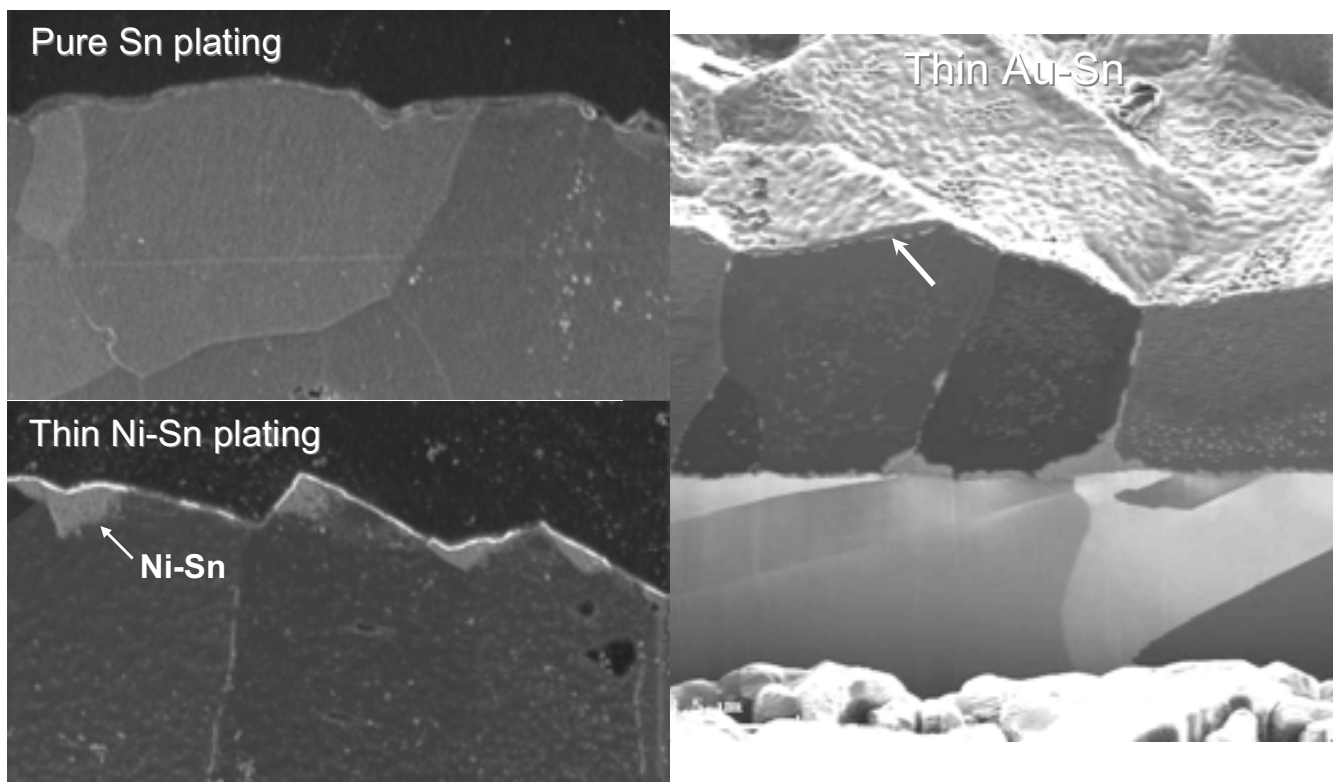
As-plated Microstructure

Surface microstructure (Au-Sn/Cu)

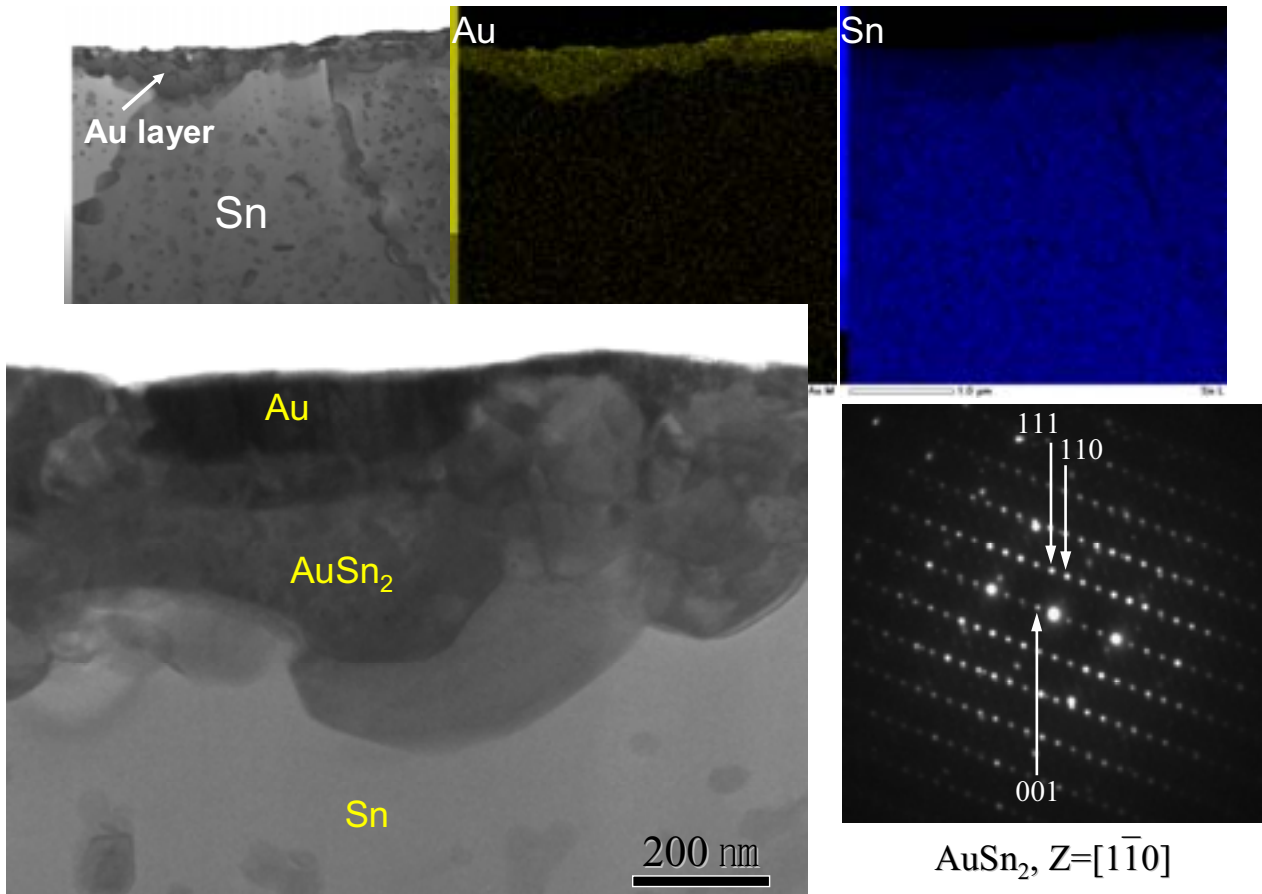


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Cross sectional microstructure



Thick Au-Sn/Cu

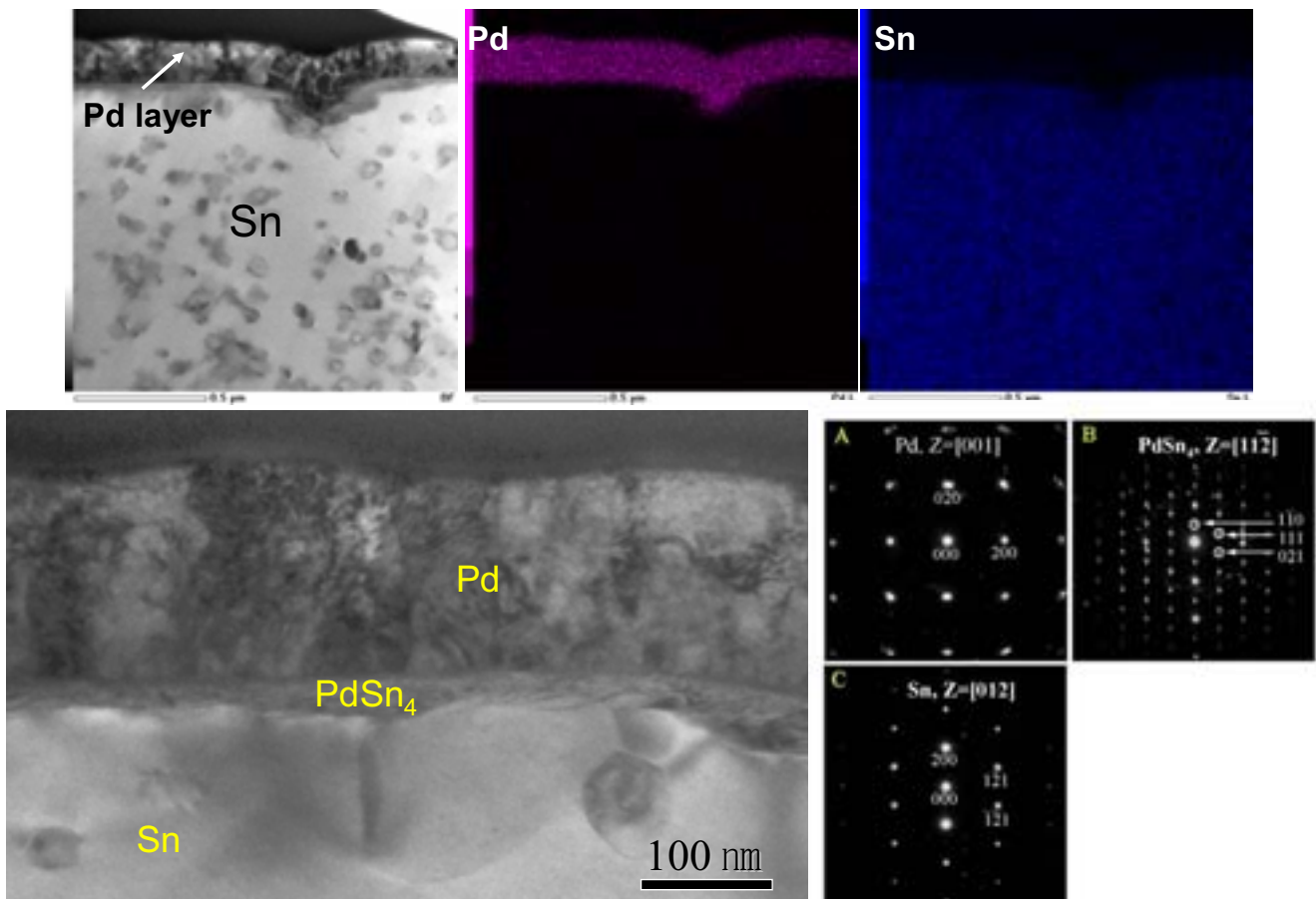


GD - By the time of microstructure analysis, a substantial fraction of the thick Au has already reacted with the Sn to form IMC.

GD - By the time of microstructure analysis, only a small fraction of the thick Pd has reacted with the Sn to form IMC.

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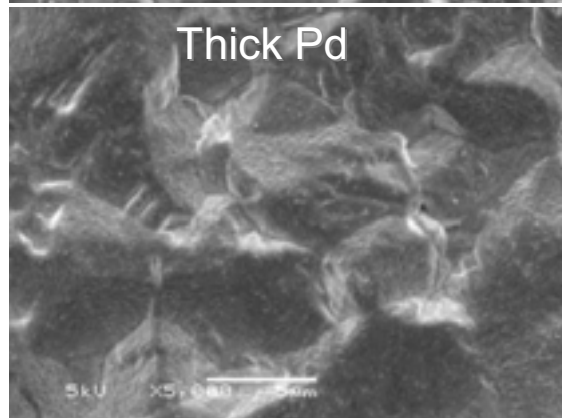
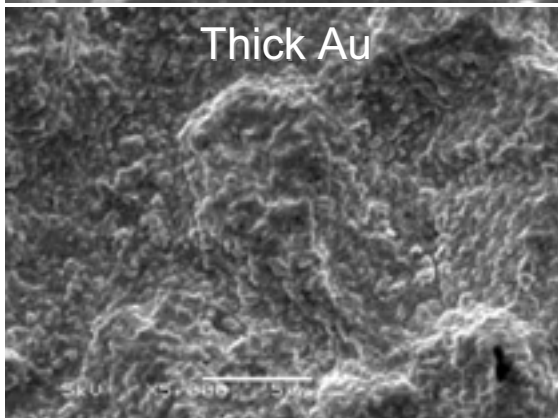
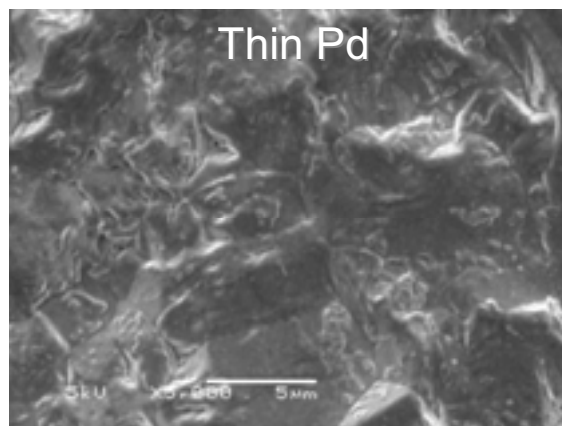
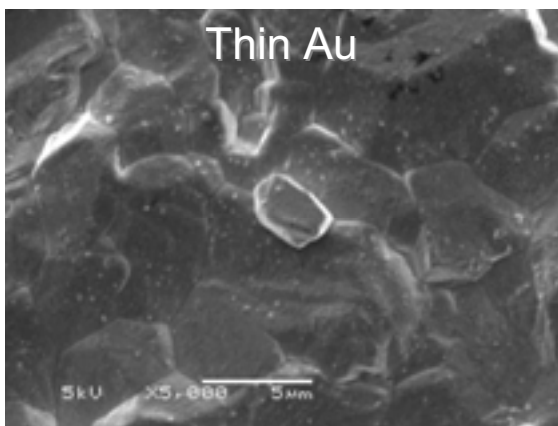
Thick Pd-Sn/Cu



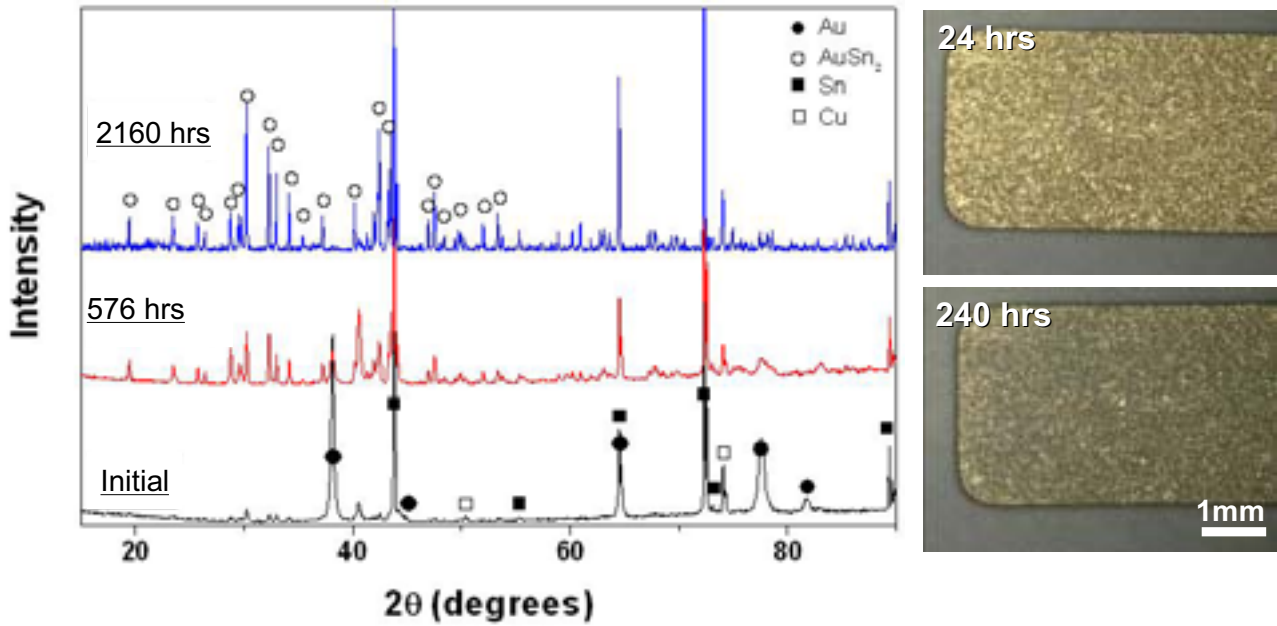
Room temperature exposure test

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Surface microstructures after RT exposure for 8400 hrs



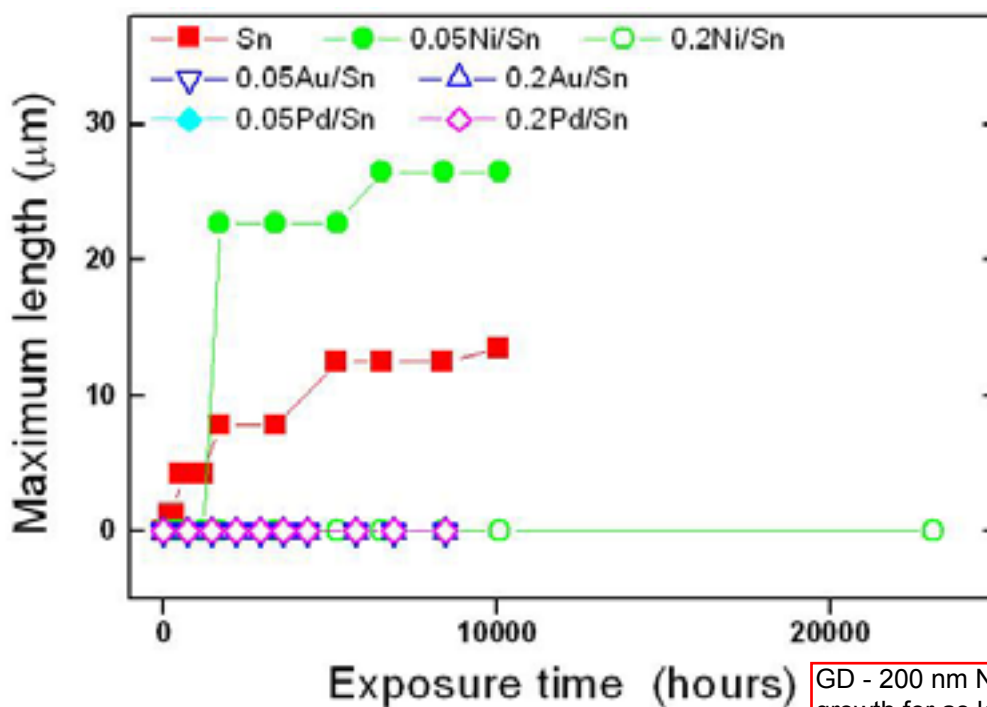
XRD analysis before/after RT exposure (thick Au)



- ✓ Au layer gradually changed to AuSn_2 phase during R.T. exposure result in the surface morphology was changed after long-term exposure.

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Changes in whisker maximum length as function of time

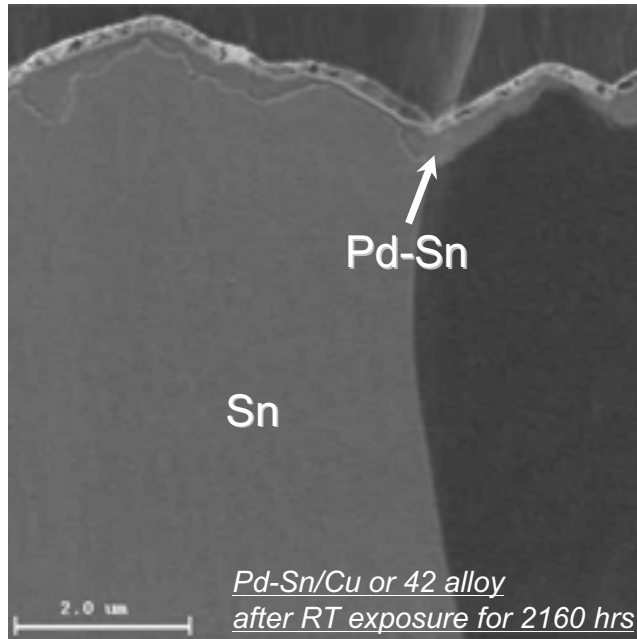


GD - 200 nm Ni suppressed whisker growth for as long as data were reported (~3 yrs).

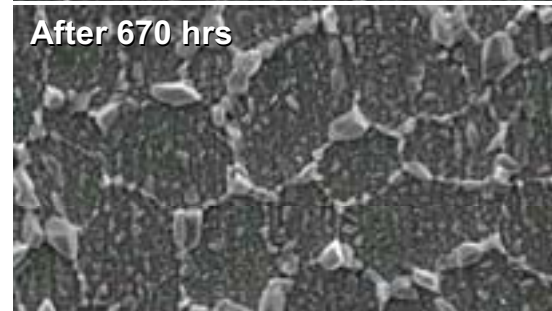
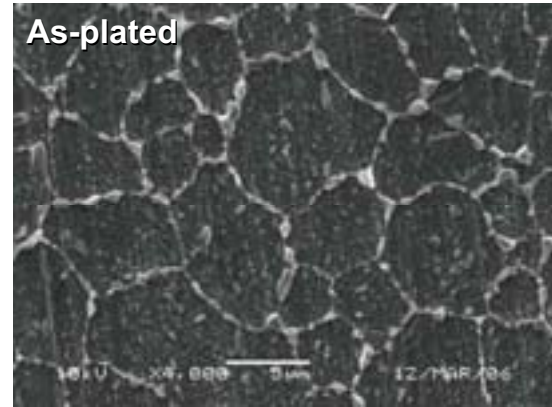
- ✓ No whisker is formed on thin and thick Au or Pd/Sn plating

GD - Au and Pd/Sn (thin or thick) suppressed whisker growth for as long as data were reported (~8000 hrs).

Summarizing the Sn whisker formation behavior during R.T. exposure



- ✓ Metal layers are very uniform and stable during R.T exposure, thus, it acts as protective layer of Sn whisker nucleation on Sn plating surface.

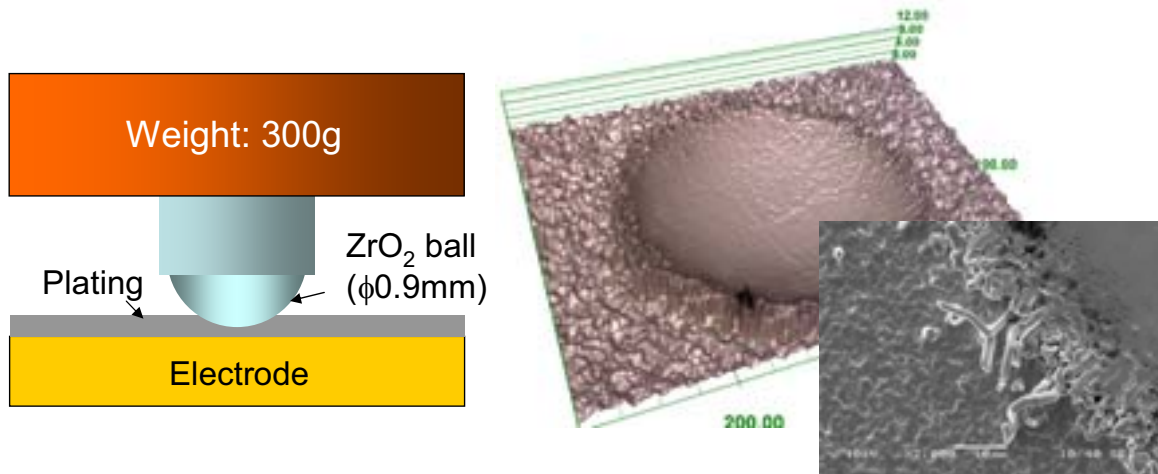


Growth of IMCs between Sn and Cu during RT exposure

GD - Even though Pd-Sn IMC has formed after 3 mo. at RT a continuous layer of Pd remains.

Static indentation loading test

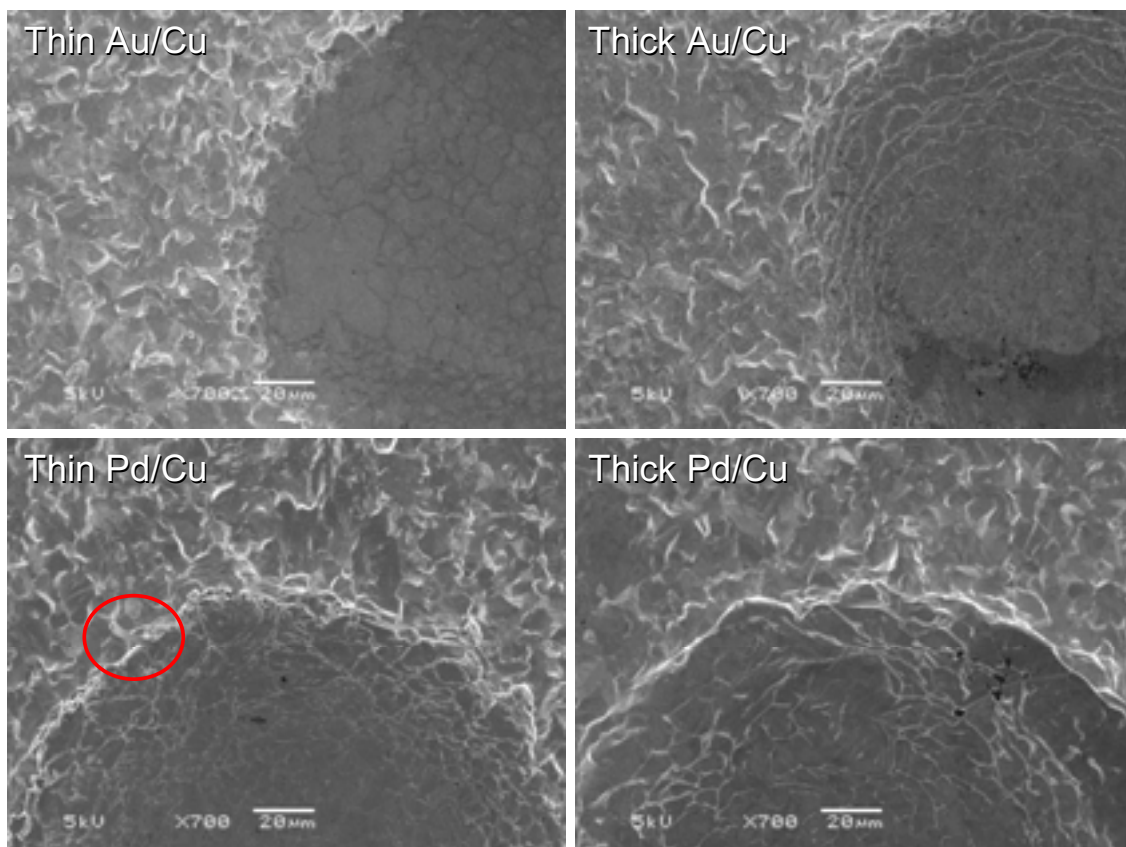
Experimental details



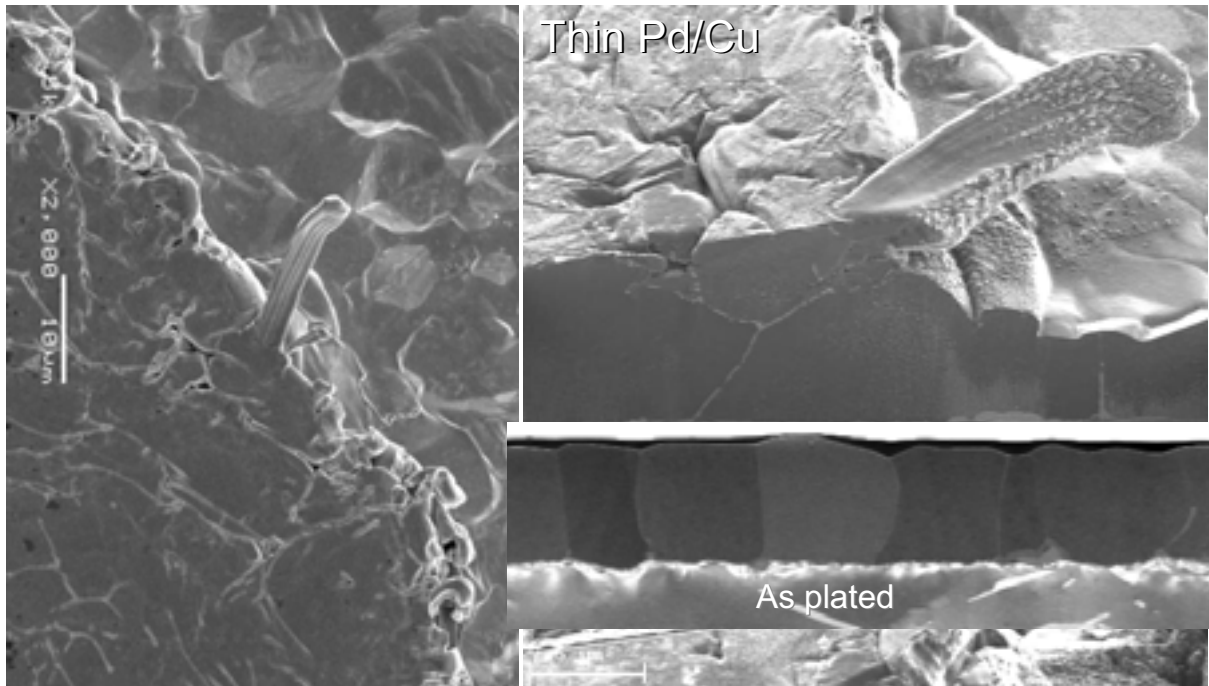
- Plating: pure Sn(t:6 μ m), thin and thick Ni, Au, Pd-Sn plating
- Electrode: Cu, 42 alloy
- Loading time: 24~240 hours

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Surface Observation (168 hrs)



Cross sectional microstructure (168 hrs)



✓ Sn whiskers are formed at surface where the Pd layer is broken.

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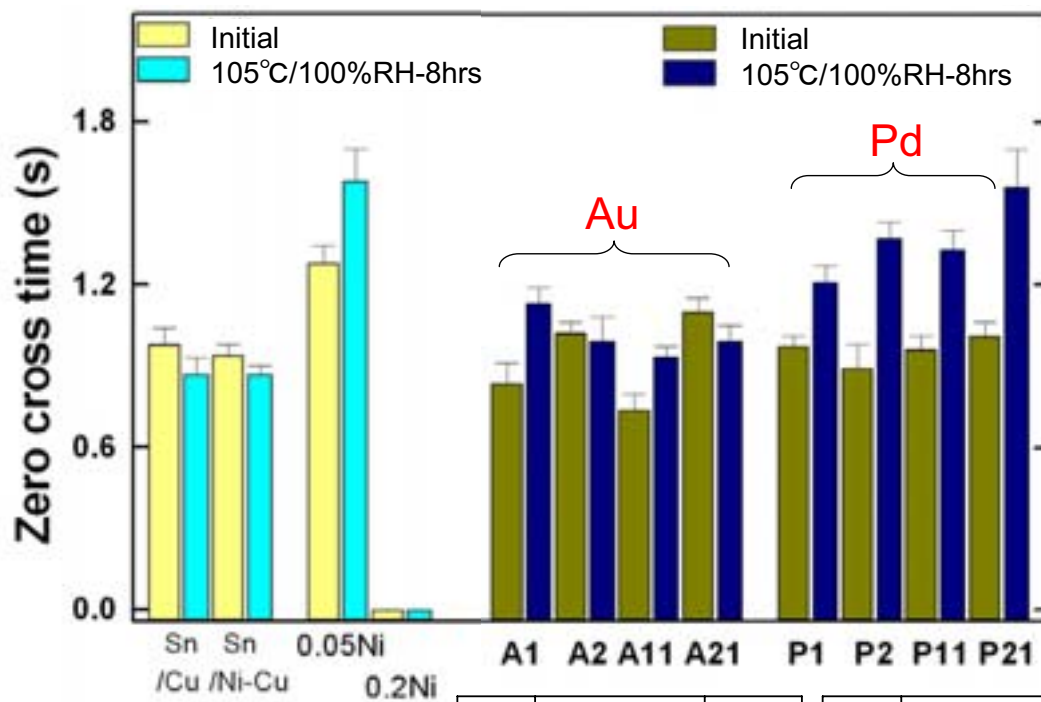
Changes in Sn whisker length (Thin layer)

Plating	Electrode	24hrs	72hrs	120hrs
Sn	Cu	≤10 μm	≤10 μm	≤20 μm
	42alloy	≤20 μm	≤20 μm	≤20 μm
0.05 Ni/Sn	Cu	X	X	X
	42alloy	X	≤10 μm	≤20 μm
0.05 Au/Sn	Cu	X	X	X
	42alloy	X	X	X
0.05 Pd/Sn	Cu	X	X	X
	42alloy	X	X	X

✓ Metal-Sn plating is much stable against Sn whisker formation under external applied stress condition.

Wetting test

Wetting behavior of various surface treatment samples



Wetting balance method
Solder: Sn-3Ag-0.5Cu
Flux: RMA, Temp.: 245 °C

A1	0.05 Au/Sn	Cu	P1	0.05 Pd/Sn	Cu
A2	0.05 Au/Sn	Ni/Cu	P2	0.05 Pd/Sn	Ni/Cu
A11	0.2 Au/Sn	Cu	P11	0.2 Pd/Sn	Cu
A21	0.2 Au/Sn	Ni/Cu	P21	0.2 Pd/Sn	Ni/Cu

Summary

- ✓ Au or Pd layer on Sn plating surface stop whisker formation during room temperature exposure.
- ✓ Thin and Thick Au or Pd plating form the continuous and uniform layer.
- ✓ Both Au and Pd platings form IMCs with Sn plating.
- ✓ Both Au and Pd platings has a great effect in suppressing Sn whisker formation under external indentation pressure.
- ✓ Wettings of Au or Pd plating are equivalent to Sn.