IEEE SW Test Workshop
Semiconductor Wafer Test Workshop

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Overpad Metallizations and Probe Challenges

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San Diego, CA USA

Why Packaging “stuff” at Probe Conference

- **More and more wafers with ENIG finish**
- **Reliability data applicable to contactor finishes for probes and sockets**
- **Metal to metal interactions extrapolate to probe and test**

Alternate Finishes for Bond Pads

Probing and Wirebond of Al

- If its wirebondable………….its probable!
- Root cause of both wire bond and probe issues lies at the corrosion layer at the surface of the aluminum pads.
- Eliminate the aluminum or corrosion layer and probe "should" improve.

ENIG or ENIPIG Instead of Al Pads

- ENEPIG has the following advantages compared to standard Al pads in standard and high temp applications:
- Gold wire bondable at all stages in the process
- No corrosion of the electroless nickel
- Excellent heat resistance
- ENIG can also be applied to Copper and Steel

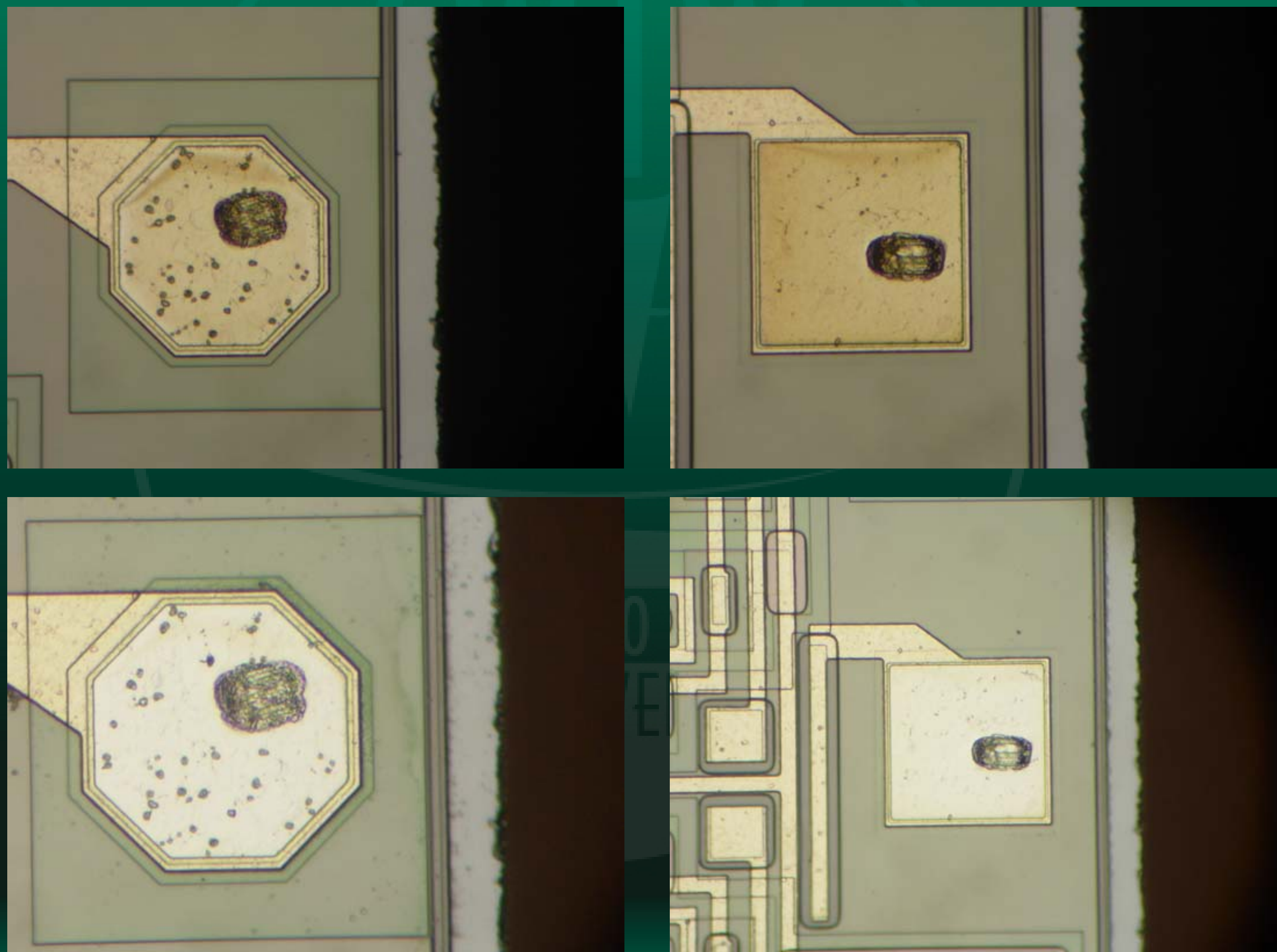
- At probe:
- Probing on Au versus Al
- Optimized probe conditions and reduced cycle time

Cleaning Improvements

As
Recvd

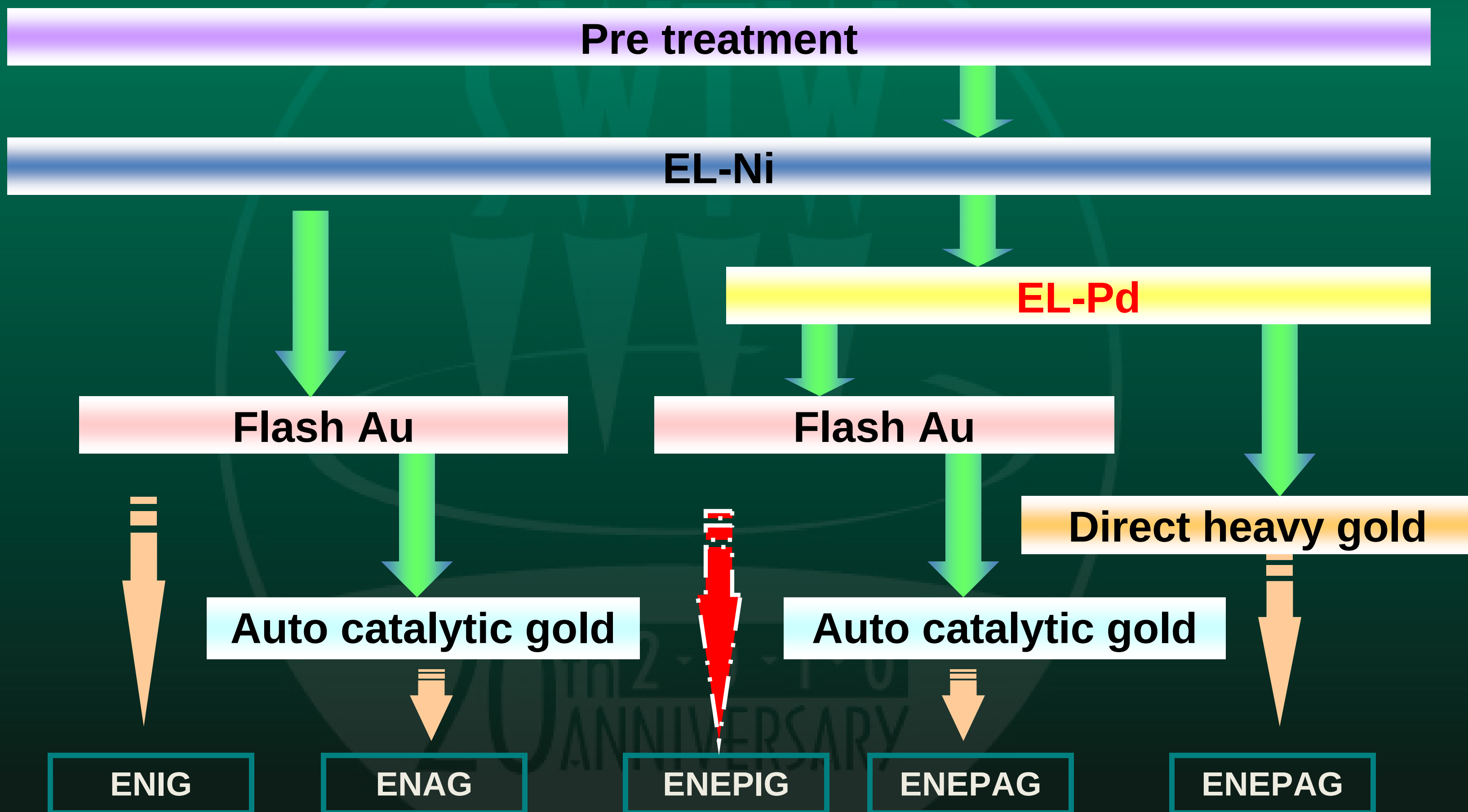
BPS100

5min



Electroless Processing of Aluminum Pads

Process for Plating Electroless NiAu NiPdAu

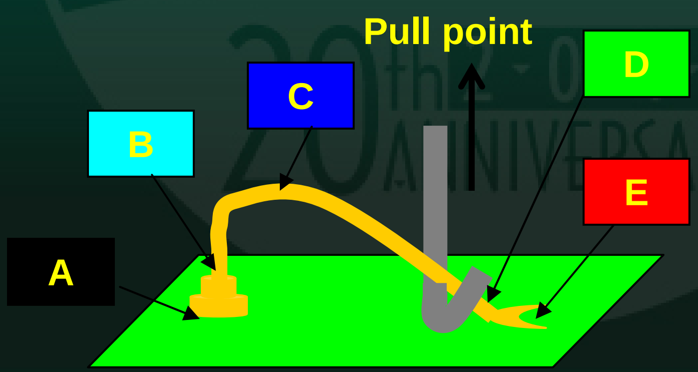


	ENIG	ENAG	ENEPIG	ENEPAG	ENEPAG
Target Gold thickness	0.03~0.06 um	0.2~0.5 um	0.03~0.06 um	0.2~0.5 um	0.1~0.3 um

Wire Bonding Reliability Test Condition

Wire bonding condition

Equipment: TPT HB16 (semi-auto wire bonder)
Capillary: B1014-51-18-12(PECO)
Wire: 1mil-gold Stage temperature: 150 deg.C
Ultra Sonic: 250mW (1st), 250mW (2nd)
Bonding Time: 200msec (1st), 50msec (2nd)
Loading force: 25g (1st), 50g (2nd)
Step: 0.700mm (1st to 2nd wire length)



Results of Wire Bond Pull Test

Heaing treatment;175deg.C-16hr.

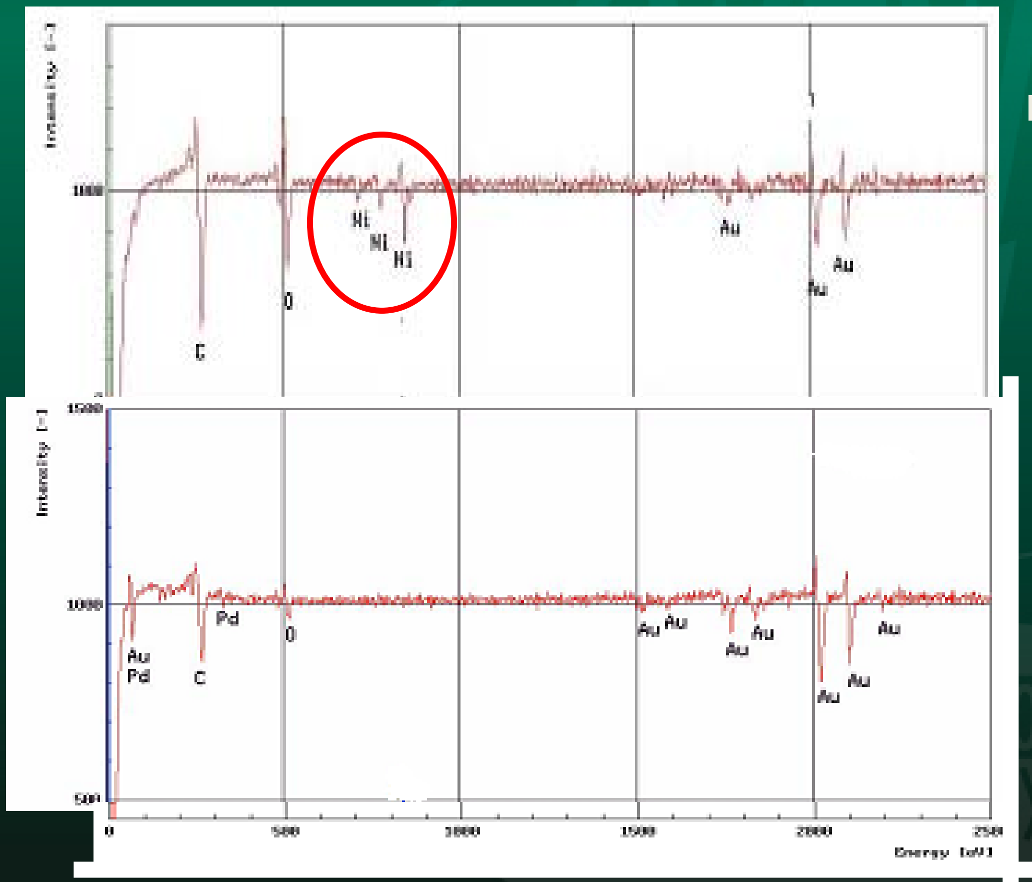
	Au thickness (um)								
Pd thickness (um)	**0.03**	**0.05**	**0.07**	**0.1**	**0.15**	**0.2**	**0.25**	**0.3**	**0.4**
0	*	4.3	4.4	3.9	3.8	3.7	5.1	8.6	9.1
0.01	6.8	7.9	7.9	8.1	8.7	8.6	9.6	10.6	10.5
0.02	6.7	7.9	8.6	8.2	8.5	9.0	9.5	10.2	10.7
0.03	6.0	7.7	8.4	8.2	8.2	9.3	9.3	10.7	10.4
0.05	6.8	7.6	8.9	8.1	8.2	9.1	9.3	10.1	10.6
0.07	7.0	7.8	8.1	8.3	8.8	9.5	9.1	10.9	11.1
0.10	6.0	6.7	8.1	8.3	8.4	9.3	9.2	10.0	10.8
0.12	7.2	8.4	8.9	8.8	8.9	9.5	9.6	10.9	10.5
0.15	6.5	8.5	8.6	8.0	9.1	9.4	10.2	10.3	10.7
0.20	6.0	8.8	8.9	8.7	9.1	9.4	10.0	10.3	10.5
0.30	6.6	8.8	8.5	8.3	9.0	9.6	10.0	10.2	10.6

	AVG. strength (g)
(blue)	more than 10
(cyan)	9 ~ 10
(yellow)	8 ~ 9
(magenta)	6 ~ 8
(red)	less than 6
*	cannot bond

- **Pd provides an excellent barrier to Ni migration through the Au**
- **15 minutes in the Pd bath typically provides 0.2um of Pd.**
- **Wire bonding strength for ENEPIG is higher than ENIG even with thin Pd thickness range.**
- **Au thickness increase shows improvement in wire bond strength while Pd thickness increase does not.**
- **Thin layer of Pd or thick gold layer. Economics or cycle time decision**

Study of Wire Bonding Reliability

AES Analysis of ENAG and ENEPIG After Heat Treatment



ENAG

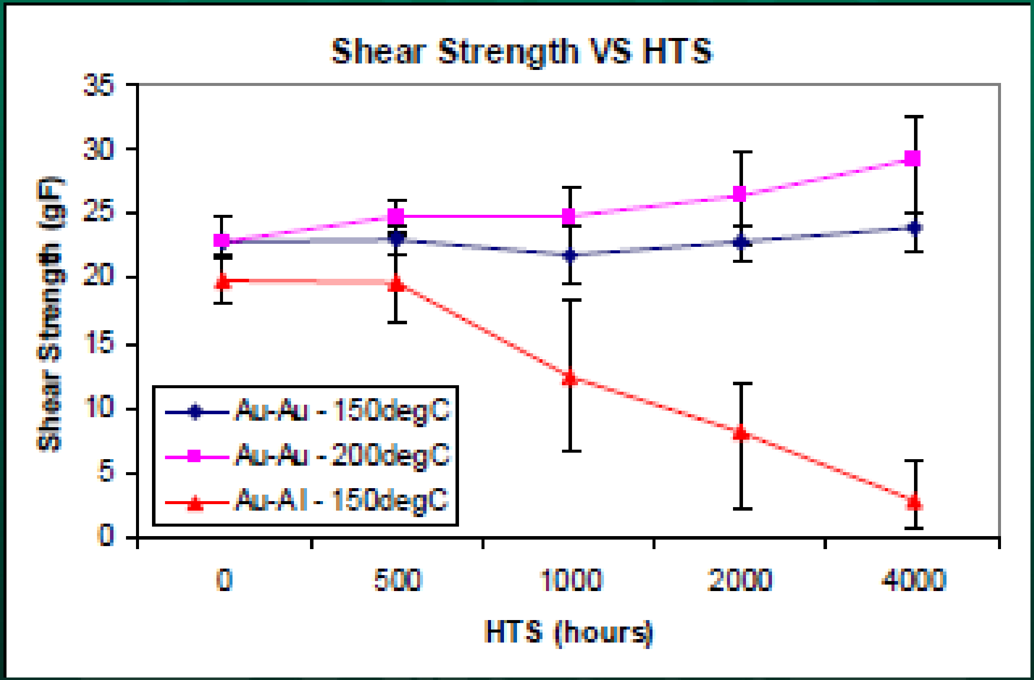
Ni = 5 um
Au = 0.2 um

ENEPIG

Ni = 5 um
Pd = 0.06 um
Au = 0.05 um

- **Even with a thin layer of Pd the analysis shows that Ni does not diffuse to the wirebond surface when using ENIPIG**

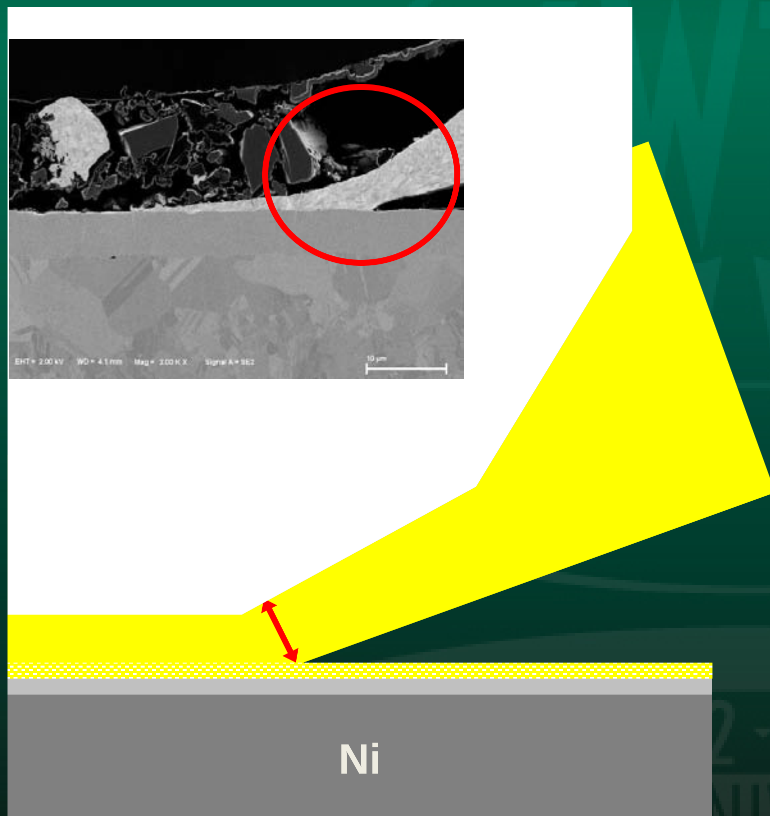
Effects of HTS on Ball Shear Strength



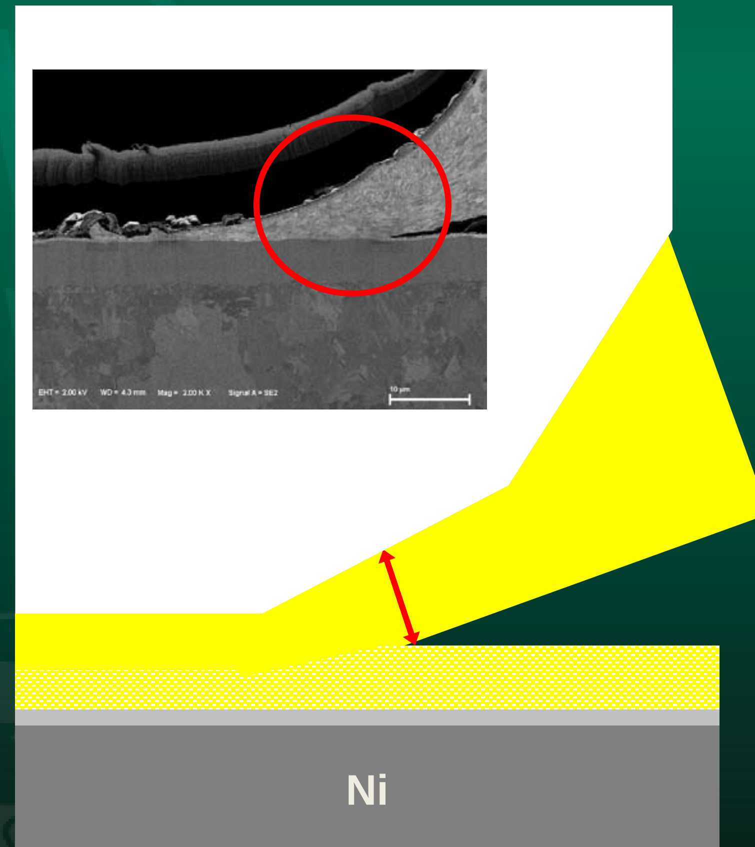
- Al-Au stable up to 500 hour then degradation begins
- Au-Au stable at all hours up to 4khrs
- Au-Au improves at higher temp likely due to solid state diffusion at the interface

Image courtesy IEEE 2006

Illustration of Wire Neck Shape by Different Gold Thickness



Au 0.05um

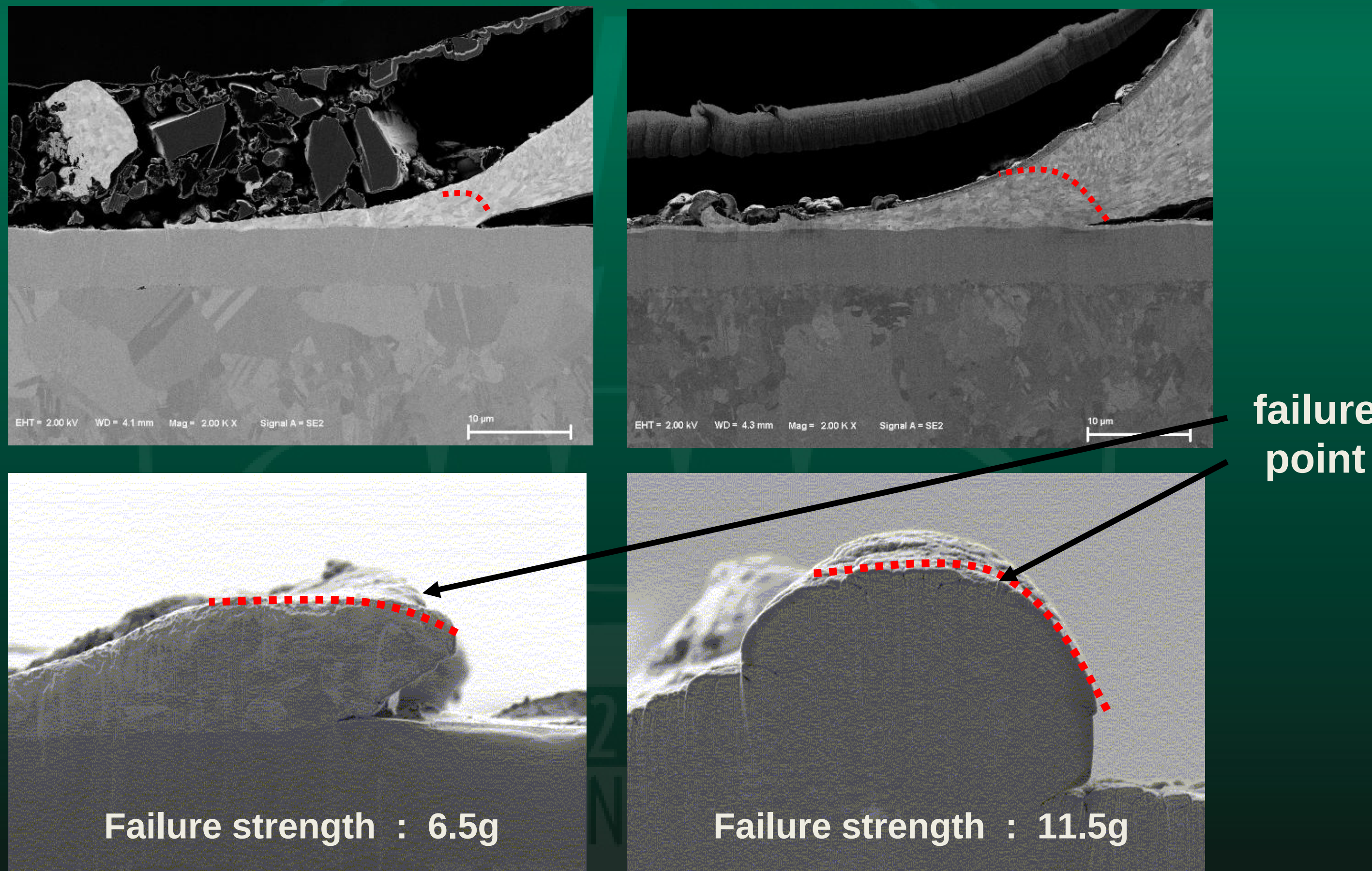


Au 0.4um

Au : 50-80Hv, Pd : 200-300Hv, Pd-P : 450-550Hv, Ni-P : 550-600Hv

- **The thickness of wire neck are different according to the cushioning properties of gold.**

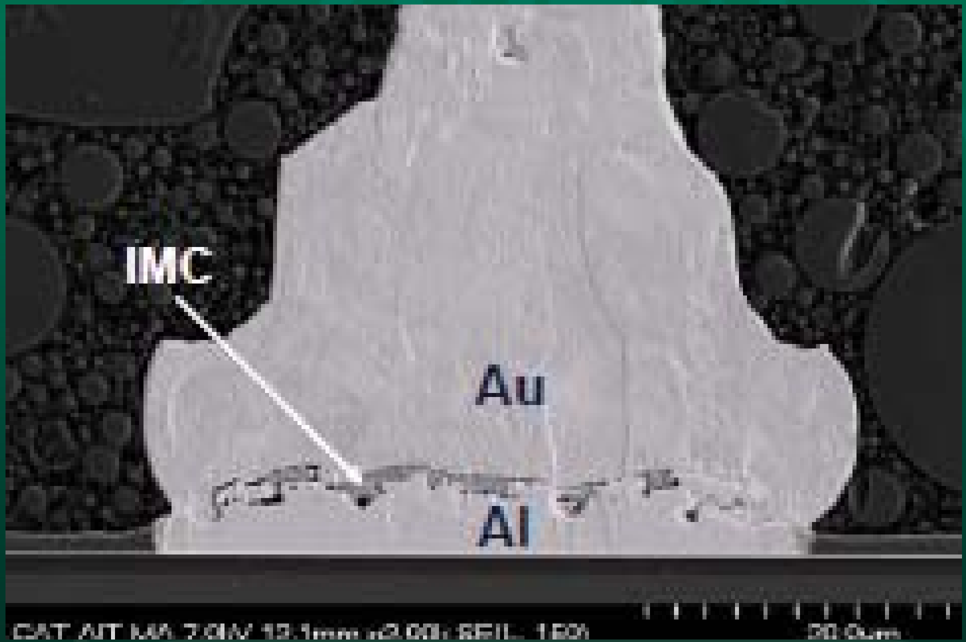
Failure Point at Different Strength After Wire Pull Test



Au 0.05um | Au 0.4um

- **The length of failure line are different compared with strong or weak strength point. The thickness of the wire just above the bonding area is markedly different.**

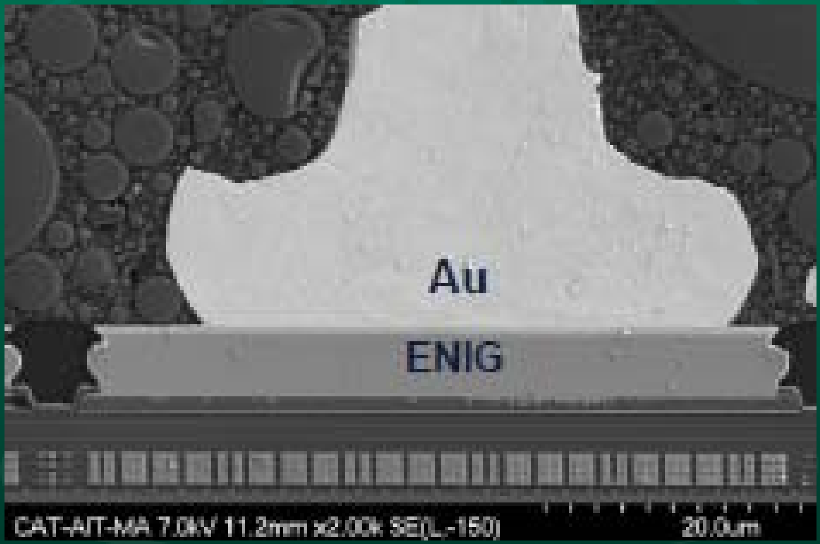
Cross Section Au-Al at 500Hrs @150C



- **No cleaning prior to wirebonding.**
- **Die were sawn in DI water with no chemistry**
- **Failures begin as early at 150 hours**
- **Failure at IMC**

Image courtesy IEEE 2006

Analysis of packaged units reliability

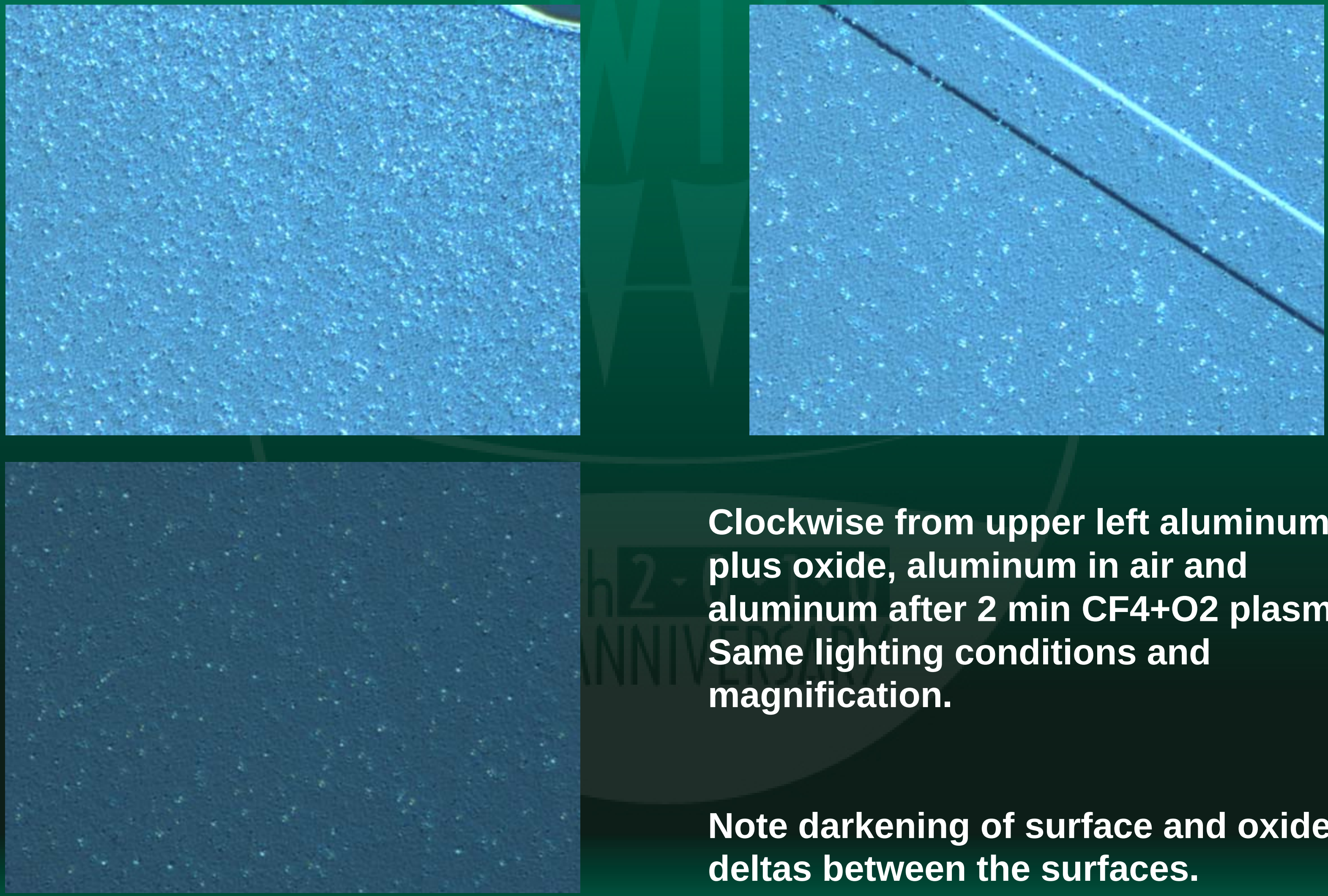


- No failures seen at 4khrs up to 200C
- No fracturing at interface.
- Reduced wirebond temp
- Less force on wire bond settings

Image courtesy IEEE 2006

Imaging of Bond Pads

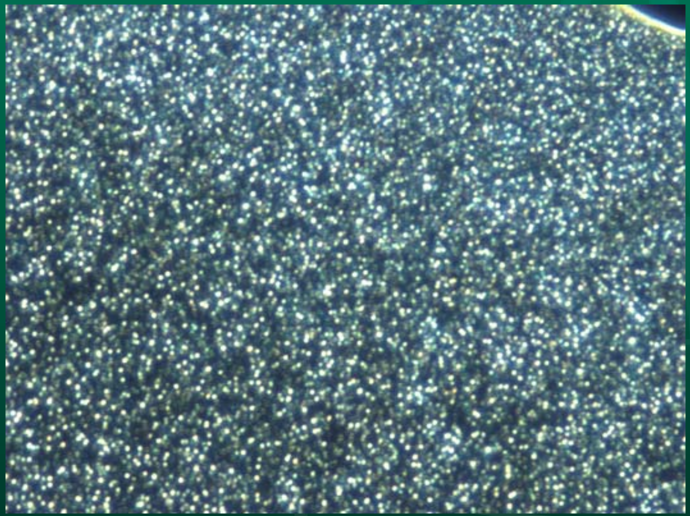
Aluminum Oxide and OF

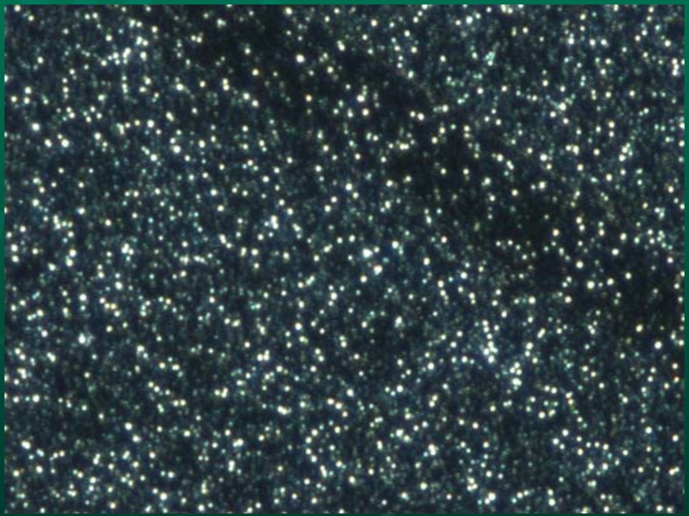


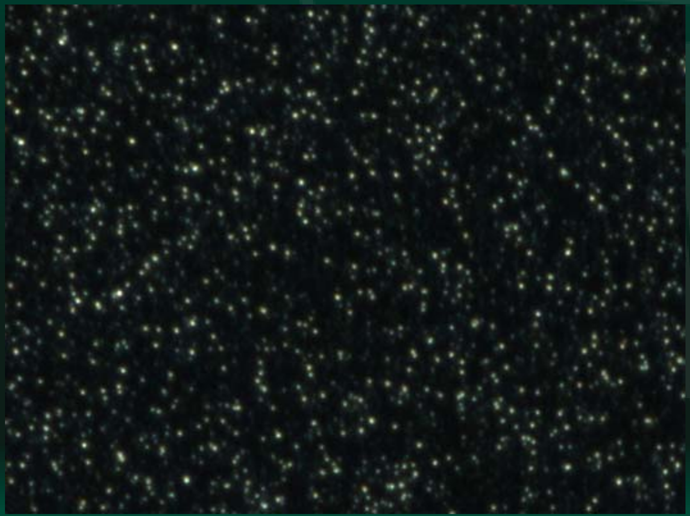
Clockwise from upper left aluminum plus oxide, aluminum in air and aluminum after 2 min CF_4+O_2 plasma. Same lighting conditions and magnification.

Note darkening of surface and oxide deltas between the surfaces.

Aluminum Oxide and OF -II







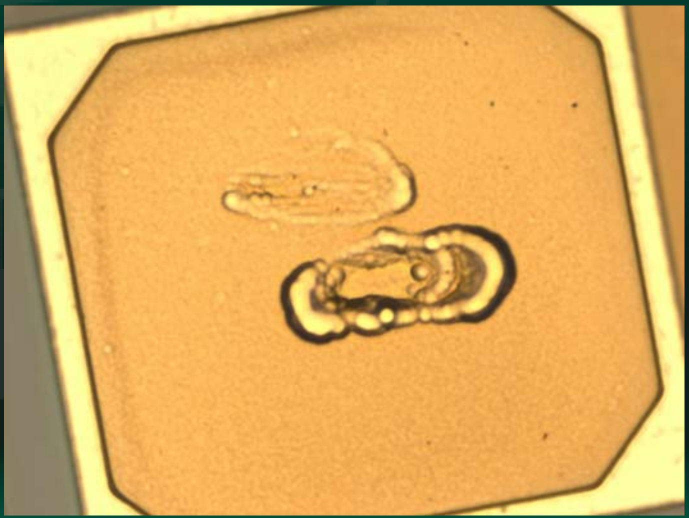
Clockwise from upper left aluminum plus oxide, aluminum in air and aluminum after 2 min CF4+O2 plasma. Same lighting conditions and magnification.

Note the refractive layer diminishes with processing and is replaced by the CRES layer.

Pad Conditions Pre and Post ENIPIG

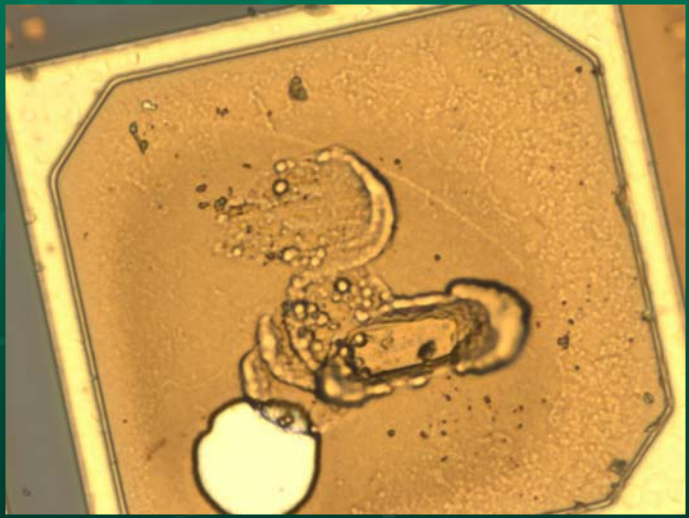
- Top pad cleaned in BPS100 then allowed to sit in DI for 90 min
- Complete missing metal in probe mark

- Bottom pad has ENIPIG
- Probe mark is filled with new metal
- Smooth finish on plating

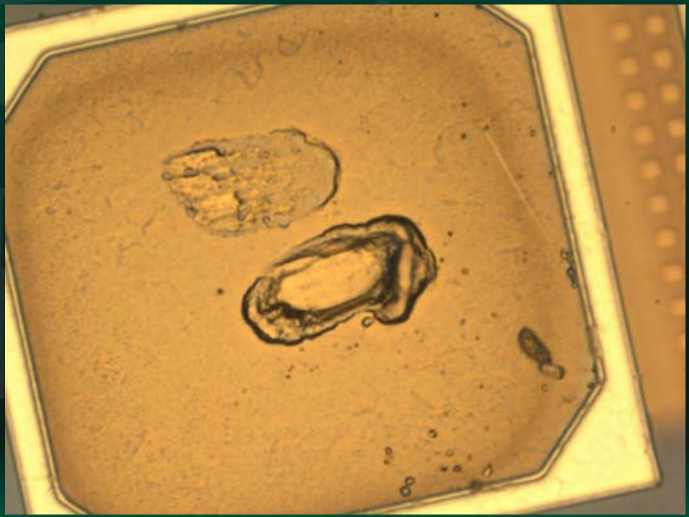


Cleaning with w/ and w/o BPS100

- Pads on the top were not cleaned prior to ENIG process
- Incomplete coverage and rougher surface



- Bottom die has been cleaned with BPS100 prior to processing.
- Complete coverage



Wirebondability

	Wire bondable t=0	Wire bondable t=24hrs	Wire bondable t=72
Bare aluminum	Marginal	No	No
Cleaned aluminum	Good	Marginal	No
Cleaned aluminum +DI water soak	No	No	No
ENIG	Yes	Slightly marginal	No
ENIPIG	Yes	Yes	yes
Ni/PdCo/Au	Yes	Yes	Yes

In many cases the NiPd and NiPdCo remains wirebondable without gold

Summary

- Conditions at probe and wirebond show a similar root cause for poor process control
- Wire bonding on plated parts compared to bare aluminum shows marked improvement.
- Cleaning with BPS100 improves the ENIG process.
- **Wire bonding strength for ENEPIG is higher even with low Pd thickness range.**
- Nickel does not diffuse to the top surface with heat treatment even if Pd and Au are thin.
- **Increasing Au thickness shows improvement in wire bond strength while increased Pd thickness does not.**
- The thickness of wire neck are different according to cushioning properties of the gold deposit.

Thank You!

Thank you for taking time to listing to this presentation.

Special thanks to:
Uyemura International Corporation
Don Gudeczauskas for assisting with ENIG/ENIPIG support.

Questions?