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Electronic Materials

Versatile Lead-Free Solder Electroplating Products for Advanced Bumping Technologies

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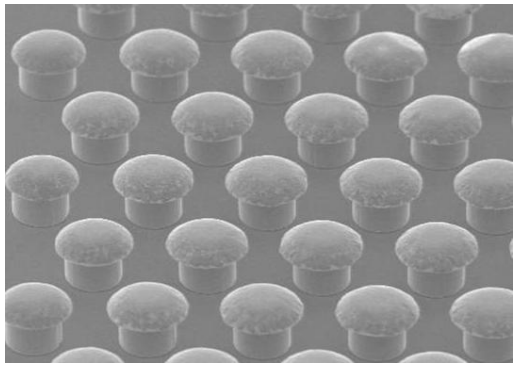
Advanced Packaging Technologies

Outline

- Background
- Introduction of the lead-free solder electroplating products - SOLDERON™ BP TS 6000 SnAg Plating Bath –
- TS 6000 SnAg process performance
- TS 6000 SnAg process versatility
- TS 6000 SnAg process robustness
- Conclusion

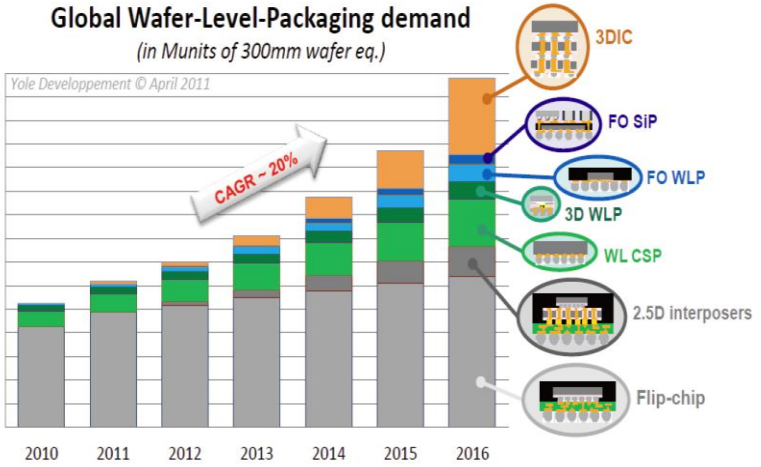


Background

- Lead-free SnAg solder bumps are used extensively in the high volume production lines for a number of new bumping technologies
  - C4 bumping
  - Cu pillars capped with SnAg solder
  - 3D microbumps

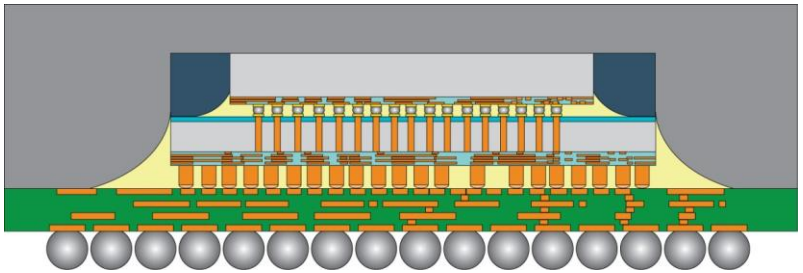
- Traditional device manufacturers, wafer foundries and OSAT companies are manufacturing various and complex bumping wafers with challenging requirements
  - Tightly controlled thickness uniformity
  - Alloy composition uniformity
  - Avoidance of reflow voids

- To meet challenging requirements, a SnAg plating chemistry must deliver versatile and robust plating process



Graphic courtesy of Yole Developpement

ETNA 3D chip stack with DRAM and Logic integration



Lead-free Solder Electroplating Solution components

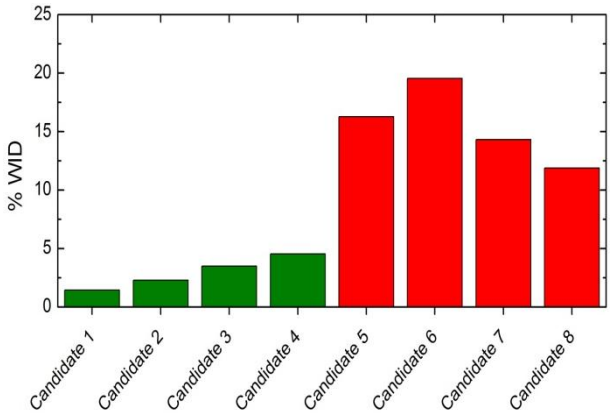
- Inorganic {Sn, Ag, Acid}
  - Provide the metal source for solder
  - Bulk electrolyte
  - pH control

- Organic Additives
  - WID and WIW height uniformity
  - Smooth as-plated morphology
  - Ag% control and uniformity
  - Stability and compatibility

SOLDERON™ BP TS 6000 Tin-Silver Plating Chemistry

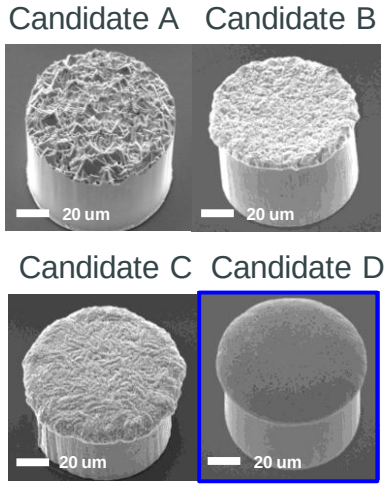
- Focus on development of a brand new additive system

For WID/WIW height uniformity



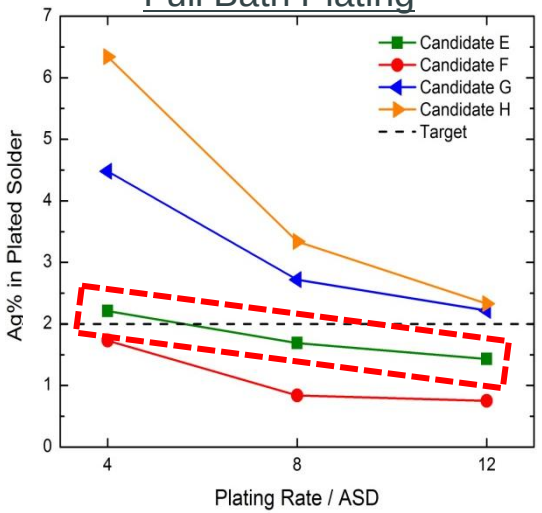
Benchtop functional testing of candidates on challenging Dow internal test vehicle at 8 ASD, measure %WID

For Surface morphology



For Ag% control

Full Bath Plating



Control Ag% composition in plated solder, allow for good uniformity and reliability, long-term bath stability

Prange, Jonathan et al. *Next-Generation Lead-Free Solder Plating Products for High Speed Bumping, Capping and Micro-Capping Applications*. in *IMAPS Conference Proceedings*. 2013. Orlando, FL.

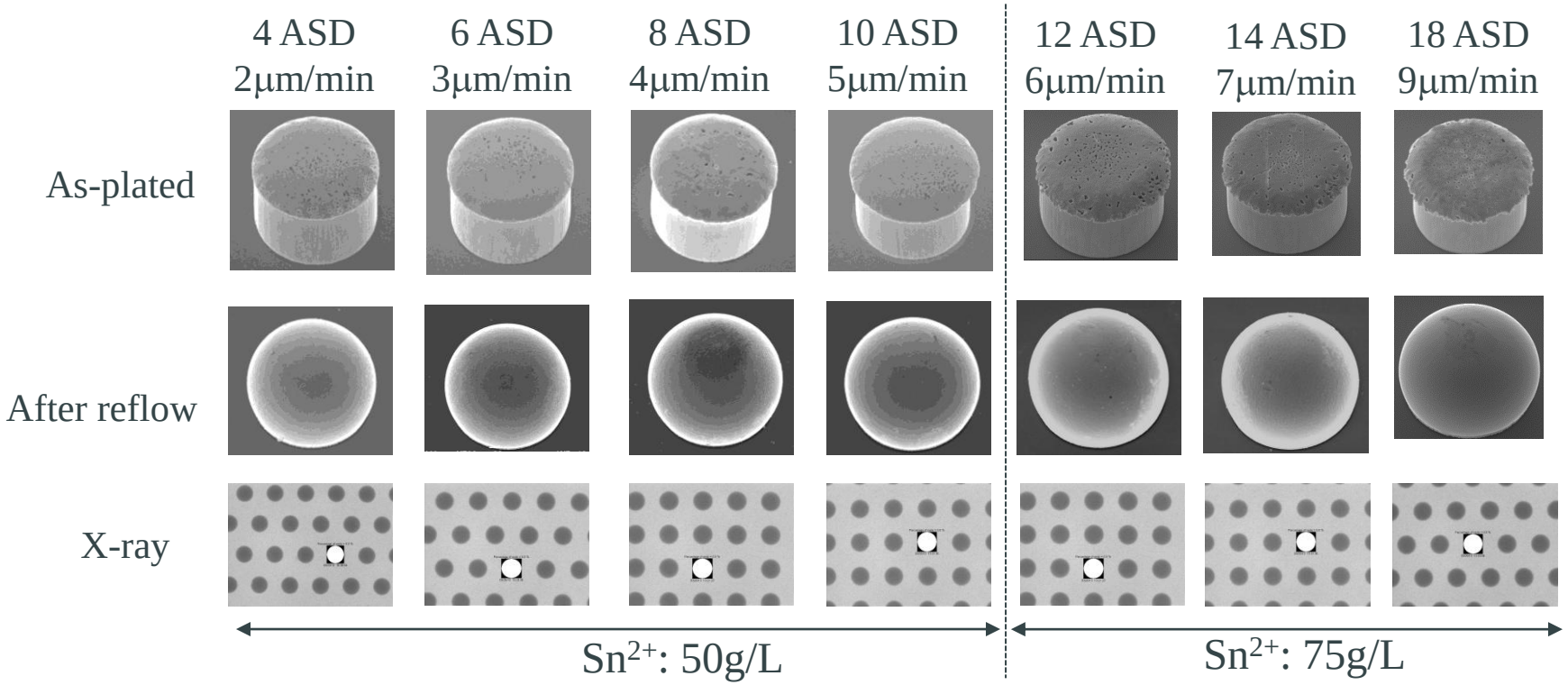
I. SOLDERON™ BP TS 6000 Tin-Silver Plating Chemistry

Process Performance

- *Morphology*
- *Bump height uniformity*
- *Ag% composition distribution*
- *Voiding*

TS 6000 Process Performance: Morphology

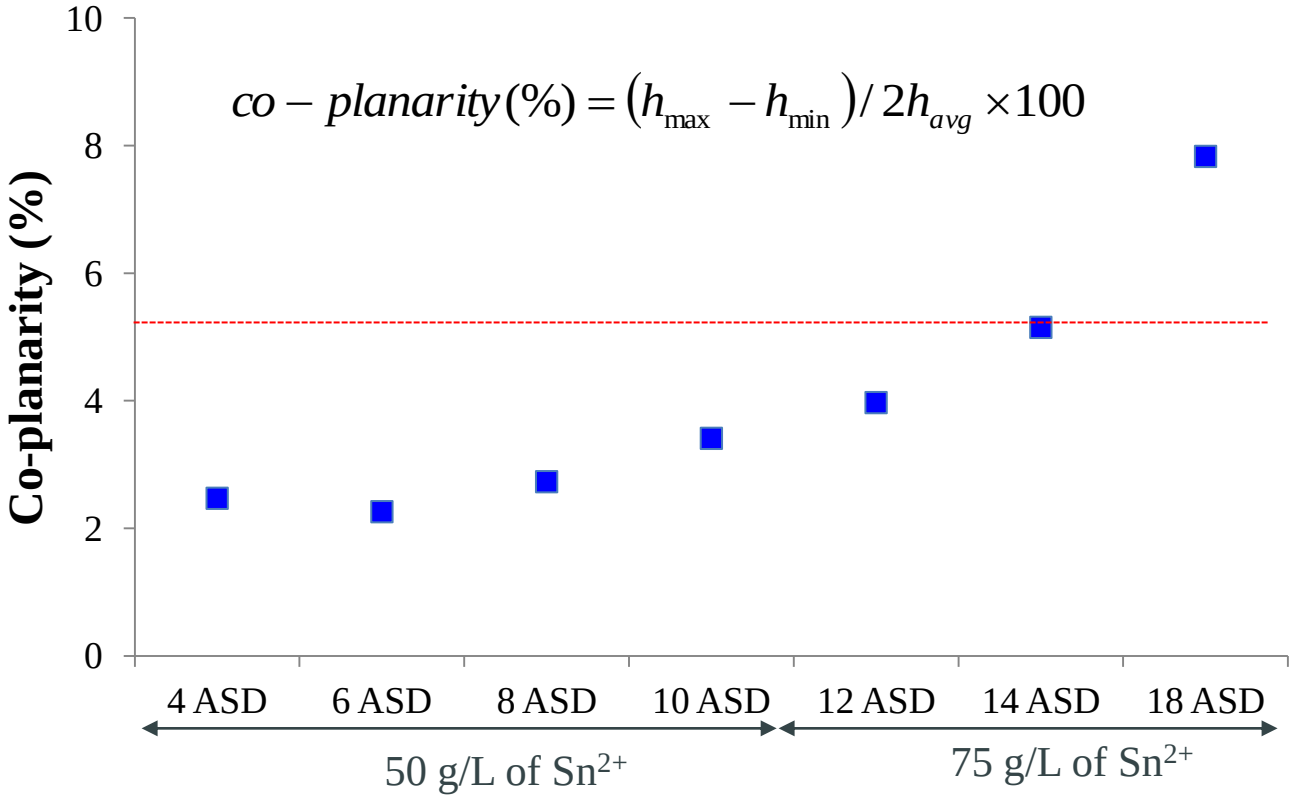
- **Surface Morphology and Voiding as function of plating rate**
  - Wafer: 300mm DOW Test vehicle
    - PR thickness: 50 μm, via diameter: 75 μm, Pitch: 150 ~ 375 μm, Open area: 15%
    - Target height after reflow: 70 μm, Mushroom plating



Consistent smooth surface morphology over the wide range of plating rate

TS 6000 Process Performance: Bump Height Uniformity

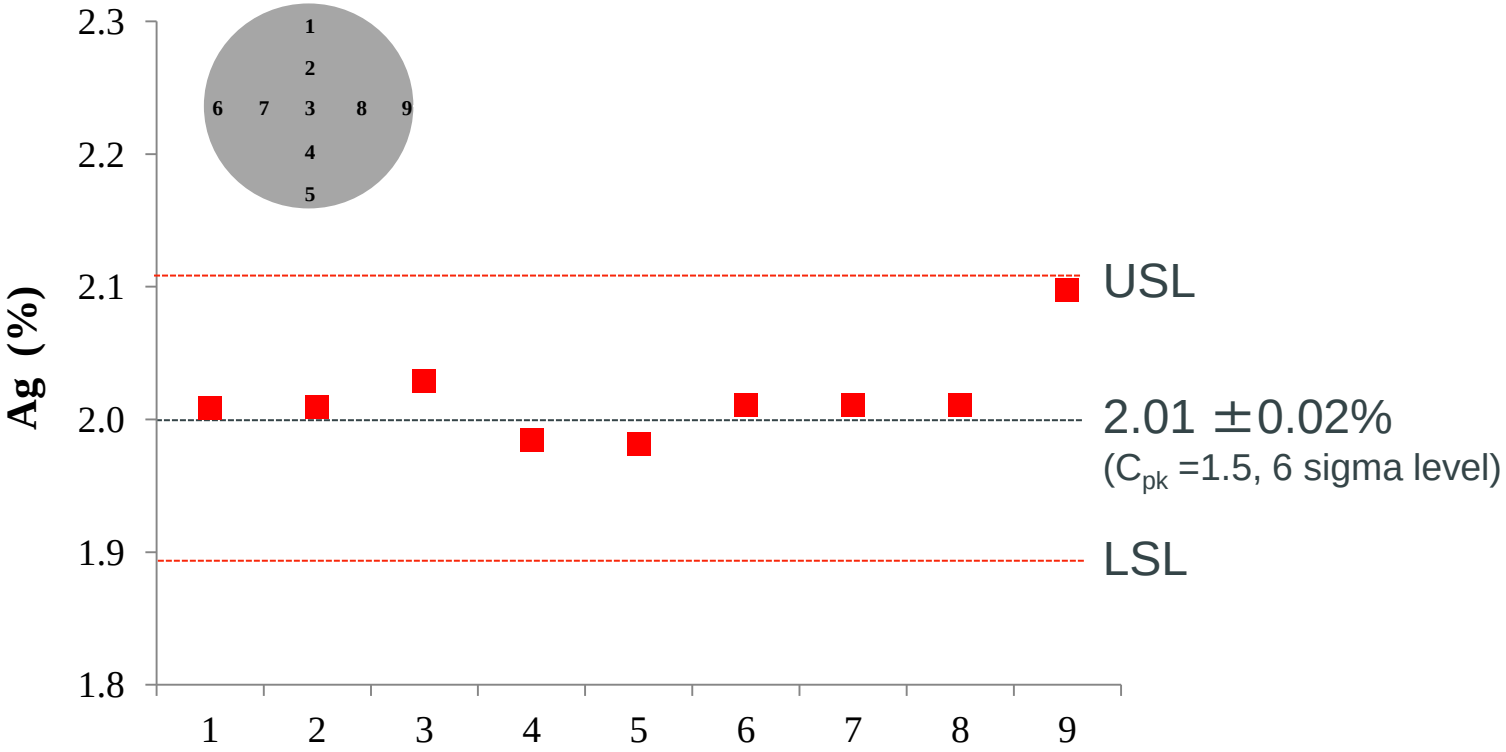
- **SnAg after reflow bump height Within die uniformity as function of plating rate**
  - Wafer: 300mm DOW Test vehicle
    - PR thickness: 50 μm, via diameter: 75 μm, Pitch: 150 ~ 375 μm, Open area: 15%
    - Target height after reflow: 70 μm, Mushroom plating



Uniform SnAg bump height over the wide range of plating rate

TS 6000 Process Performance: Ag% distribution

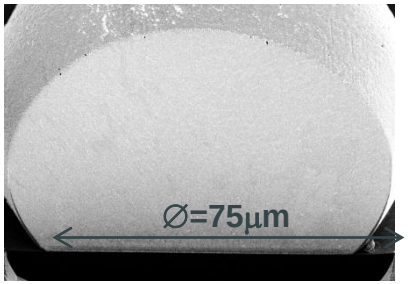
- **Ag% composition distribution across the wafer (8 ASD)**
  - Wafer: 300mm DOW Test vehicle
    - PR thickness: 50 μm, via diameter: 75 μm, Pitch: 150 ~ 375 μm, Open area: 15%
    - Target height after reflow: 70 μm, Mushroom plating

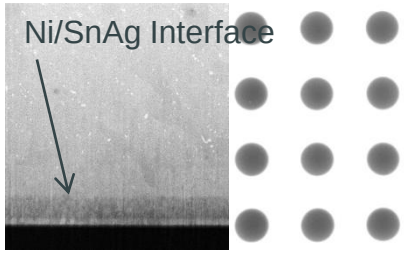


Uniform Ag% composition across the wafer

TS 6000 Process Performance: Voiding

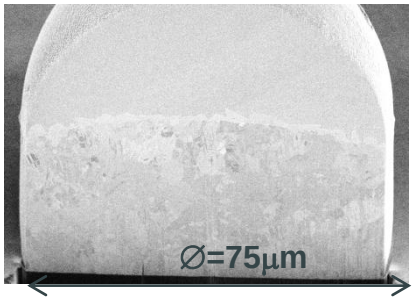
C4 SnAg Bumping





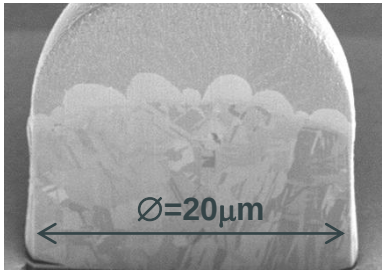
Micro-Void Free **Macro-Void Free**

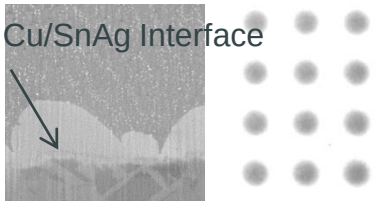
Cu Pillar Capping



Micro-Void Free **Macro-Void Free**

Cu µPillar Capping

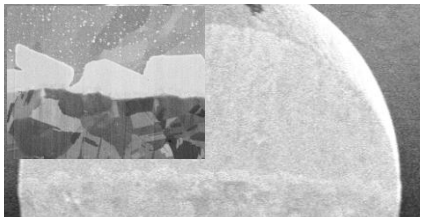




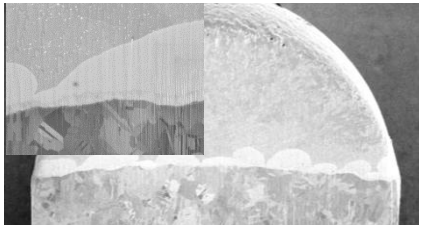
Micro-Void Free **Macro-Void Free**

Multiple reflow

1X reflow



10X reflow



- ***Micro-void free performance by FIB-SEM for C4 bumping, Cu Pillar, and Cu µPillar capping applications***
- ***Macro-void free performance by X-Ray inspection for C4 bumping, Cu Pillar, and Cu µPillar capping applications***
- ***Macro and micro void free for 1X and 10X reflow***

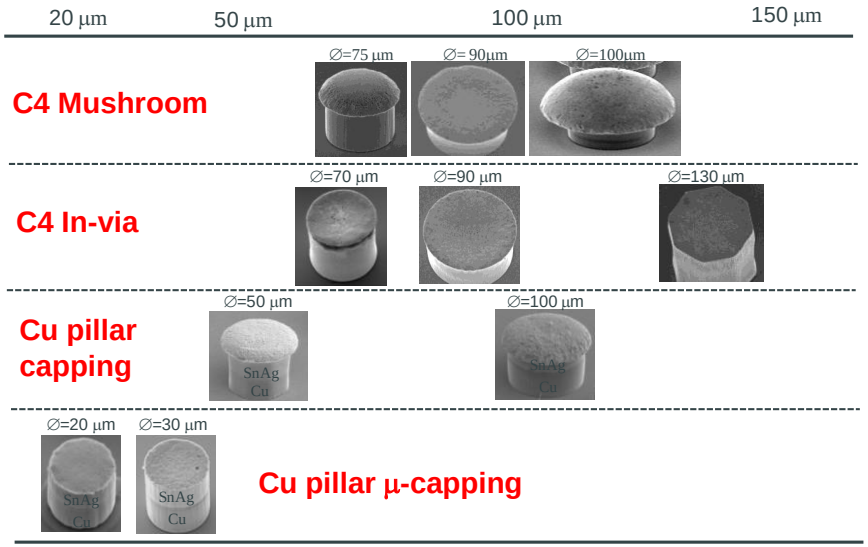
II. SOLDERON™ BP TS 6000 Tin-Silver Plating Chemistry

Process Versatility

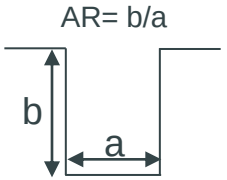
- *Various applications*
- *Various photoresists*
- *Plating tool configuration*

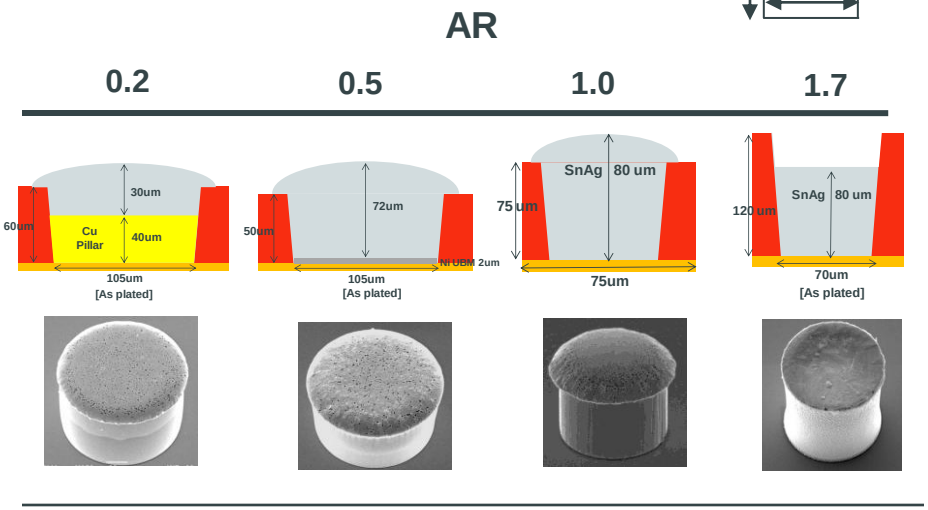
TS 6000 Process Versatility : Various Applications

SnAg bump size

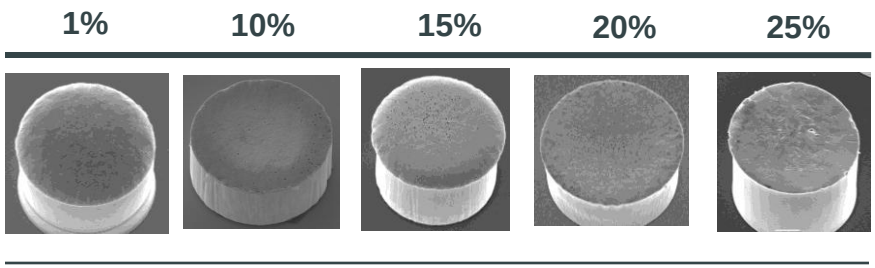


Aspect Ratio (AR)





Platable open area

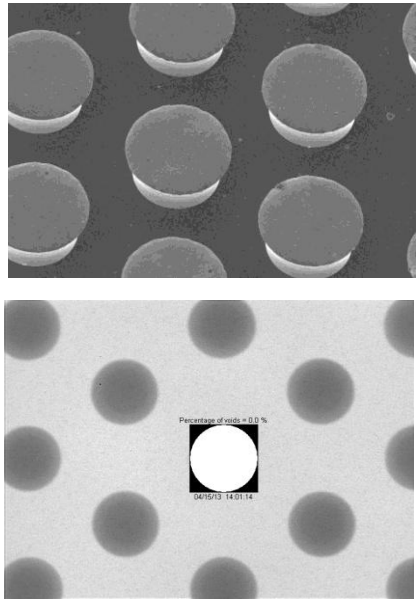


Consistent plating performance in the various applications

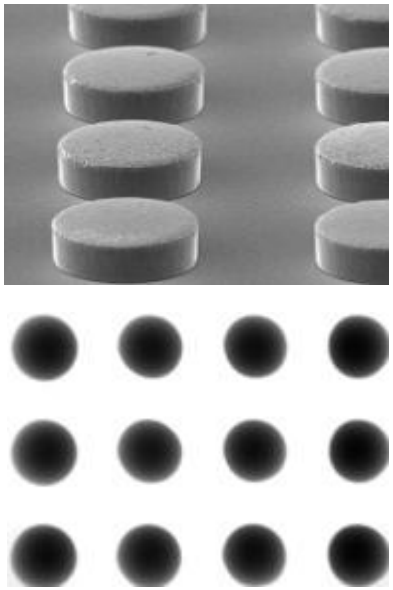
TS 6000 Process Versatility: Various Photoresists

Liquid Photoresist

Positive tone

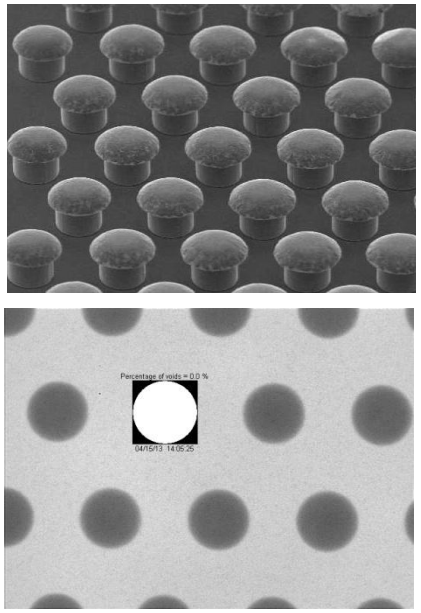


Negative tone



Dry film Photoresist

Negative tone

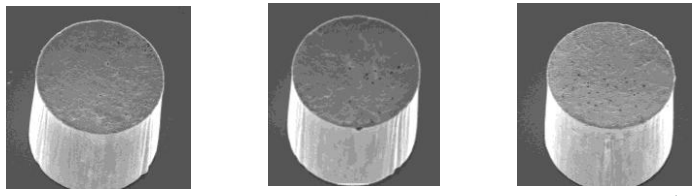


Compatible with various photoresist

TS 6000 Process Versatility: Plating Tool Configuration

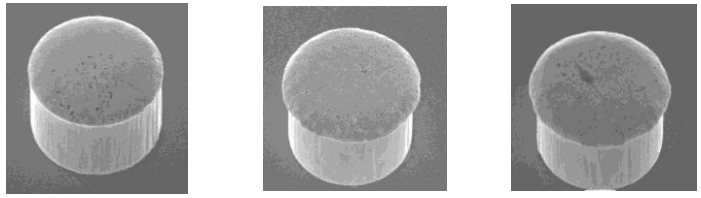
Tool A
Horizontal plating

Type A
Agitation: Rotation



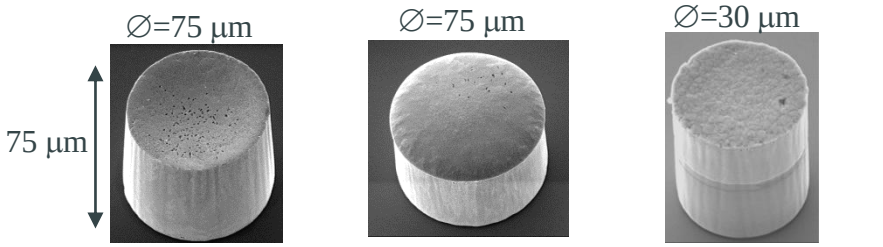
Increasing rotation speed

Type B
Agitation: Paddle



Increasing paddle speed

Tool B
Vertical plating



C4 in-via (deep via)

C4 Mushroom

Cu pillar capping

Compatible with various plating tool configuration

III. SOLDERON™ BP TS 6000 Tin-Silver Plating Chemistry

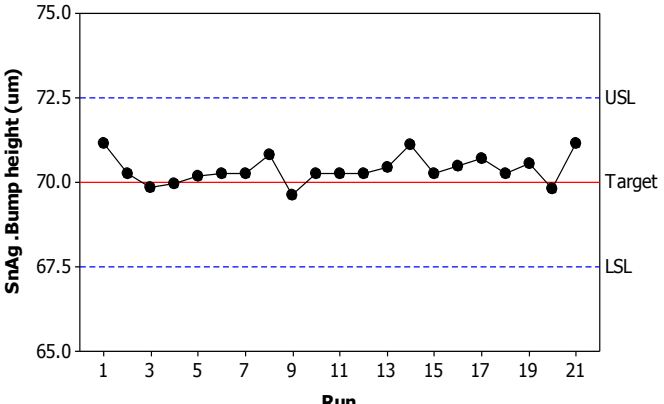
Process Robustness

- *Performance Stability*
- *Electrolytic Aging*

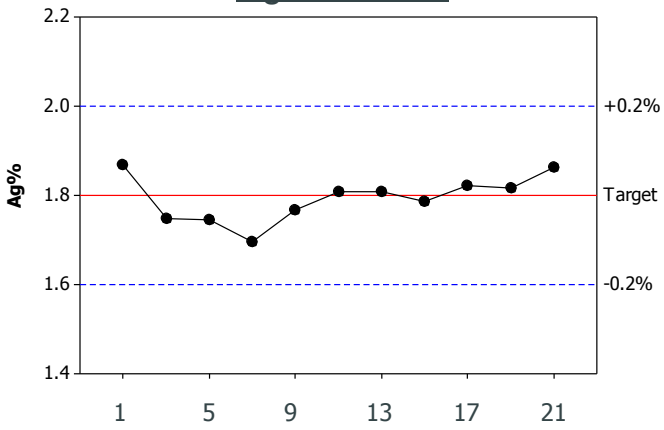
TS 6000 Process Robustness

- **TS 6000 process stability**
  - Test method: One patterned wafer plated every day for a month and monitor TS 6000 process performance.
  - Test condition: 10 ASD, mushroom plating in 300mm horizontal tool
  - Test vehicle information: PR thickness: 50 μm, via diameter: 75 μm, Open area: 20%, Target height after reflow: 70 μm

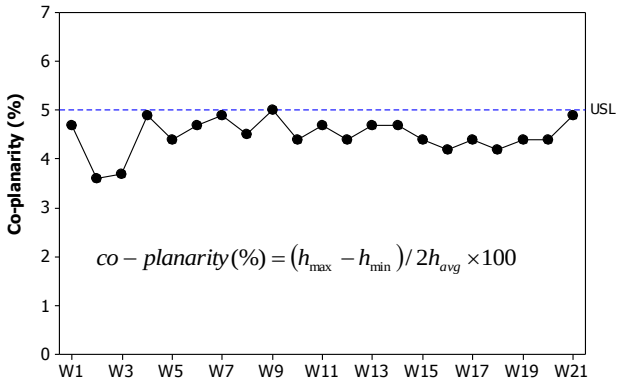
SnAg bump height



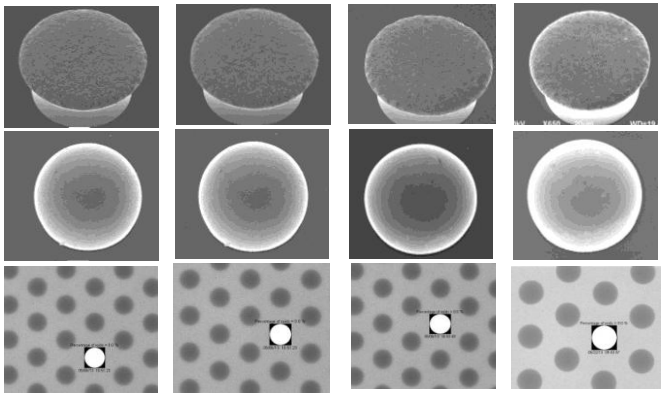
Ag% content



Within Die height uniformity (co-planarity)



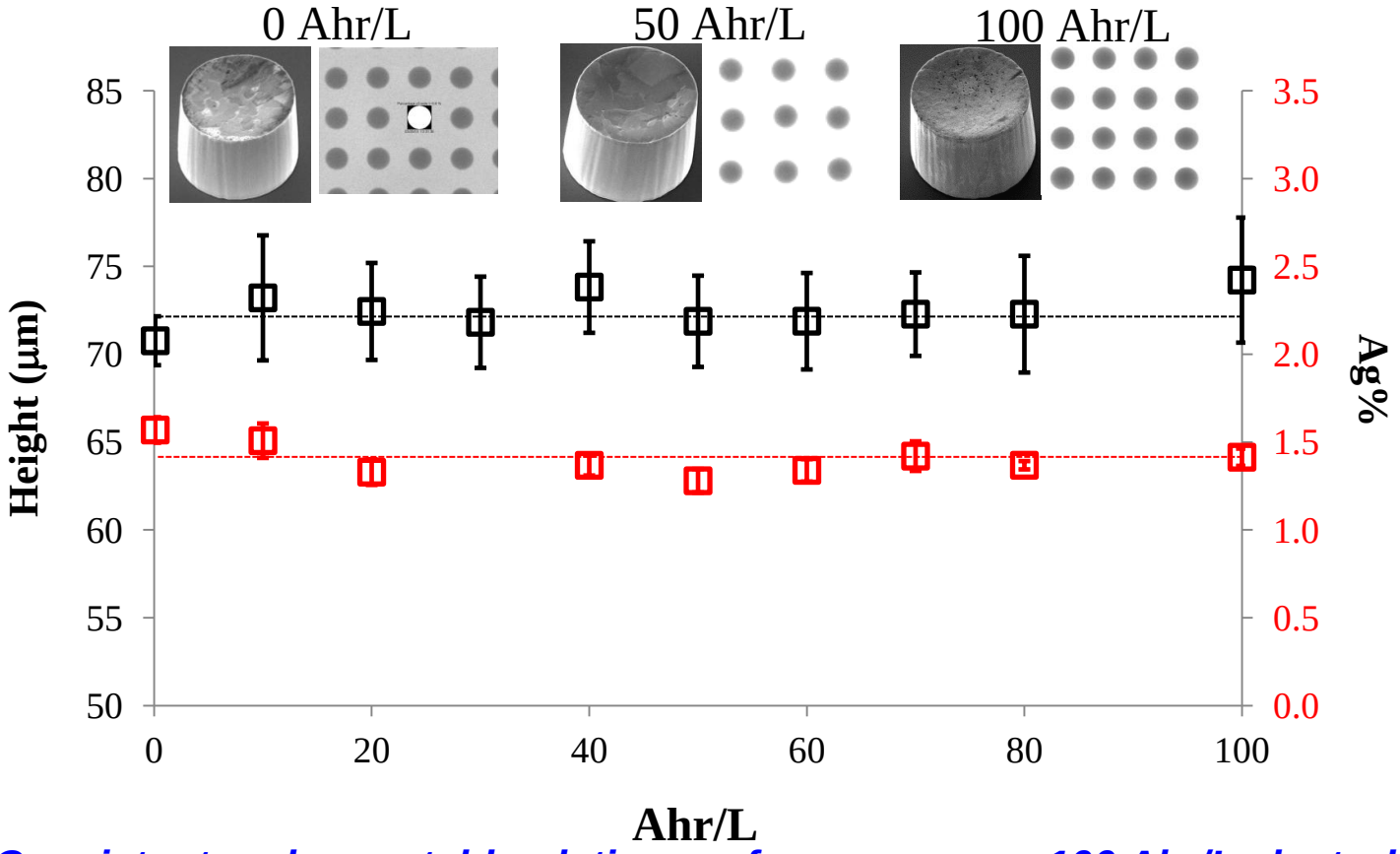
Morphology and voiding



Consistent and repeatable plating performance

TS 6000 Process Robustness

- **TS 6000 Electrolytic Aging**
  - Test method: Batch mode – only replenishment of component based on consumption rate, maintain the volume by conducting regular bleeding of the bath
  - Test condition: 8 ASD, in-via plating in 300mm vertical type plating tool
  - Test vehicle: PR thickness 120 μm, via diameter 75 μm, Open area 15%, Target height after reflow: 70 μm



Consistent and repeatable plating performance over 100 Ahr/L electrolytic aging

Conclusion

- A new SnAg electroplating product, SOLDERON™ BP TS 6000 SnAg demonstrated key performance attributes over a wide range of applications
  - Well controlled bump height uniformity
  - Tight Ag% control
  - Smooth surface morphology
  - Void free
- TS 6000 SnAg chemistry is highly versatile in a number of bumping technologies; C4 mushroom bump, C4 in-via plating, SnAg capped with Cu pillar and with Cu μ-pillar
- TS 6000 SnAg chemistry shows robust plating process with regard to plating capability, electrolytic bath aging and thermal idling

Thank You

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