Precise underfill dispense in high-throughput chip-on-wafer packaging

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Underfill for chip level packaging

- Outline
  - Underfill process
  - Chip level underfill: chip-on-wafer, chip-on-BGA
  - Challenge and solution
  - Advantage of high end dispenser
- Summary

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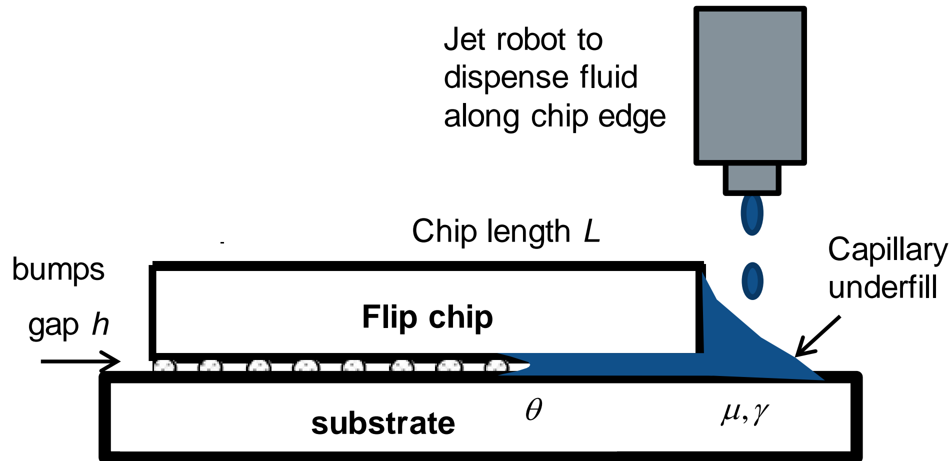
Capillary underfill for flip chip packaging

Schematic of flip chip underfill



Capillary underfill

Underfill: fluid flows into the gap by capillary force

Capillary flow out time

$$T = 3\mu L^2 / (h\gamma \cos\theta)$$

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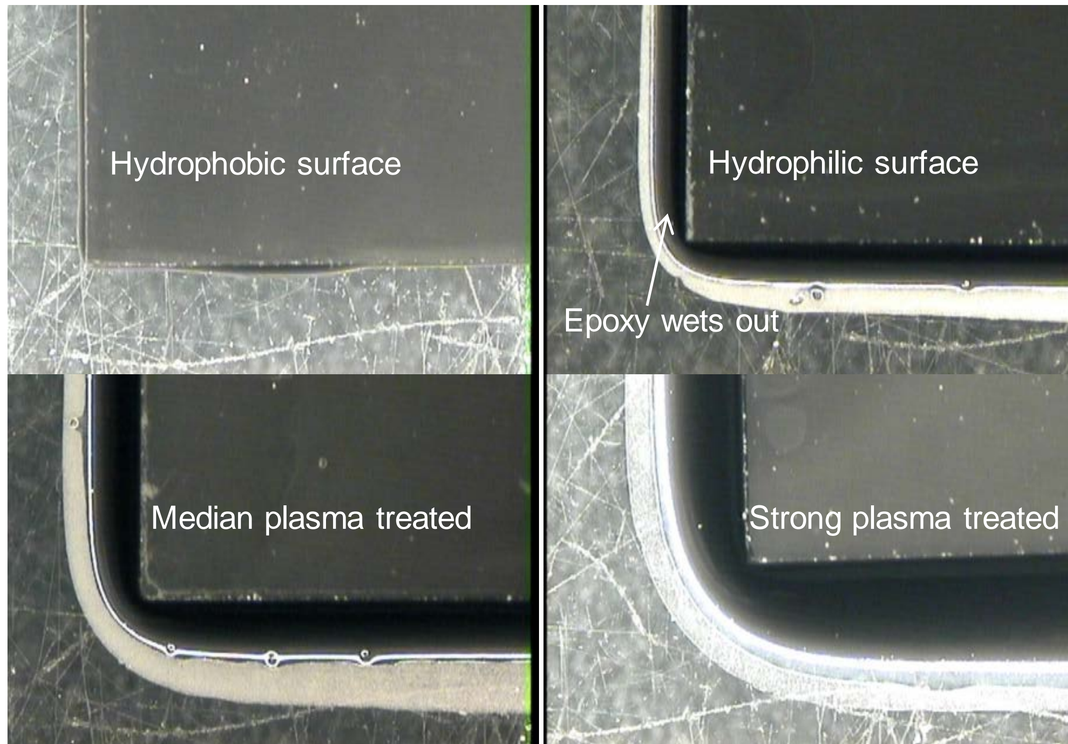
Underfill: epoxy wet-out zone



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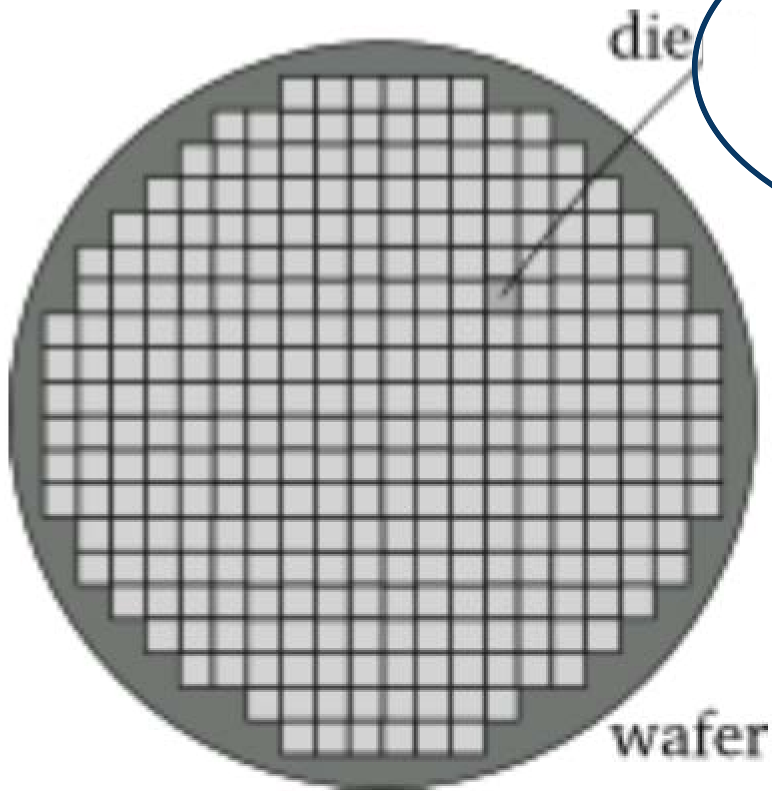
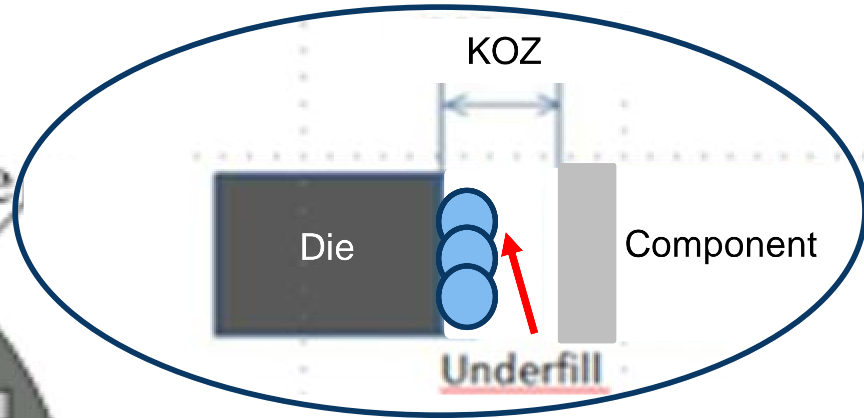
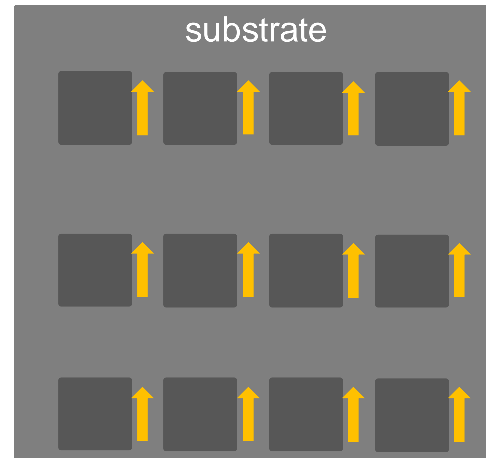
Chip-on-wafer underfill

KOZ 5-10mm for board level underfill
<1mm for today's chip-level UF







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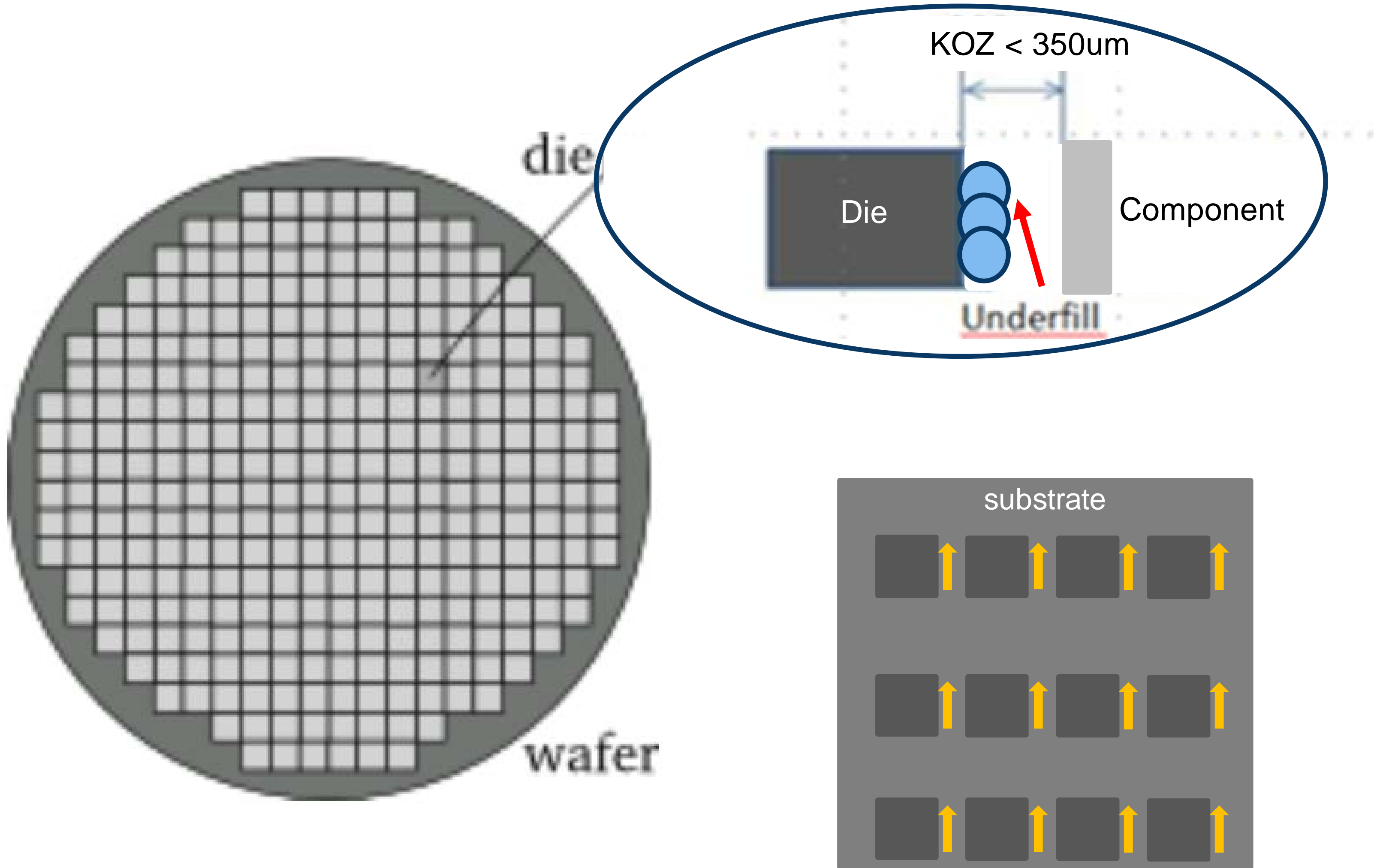
Chip-on-wafer underfill



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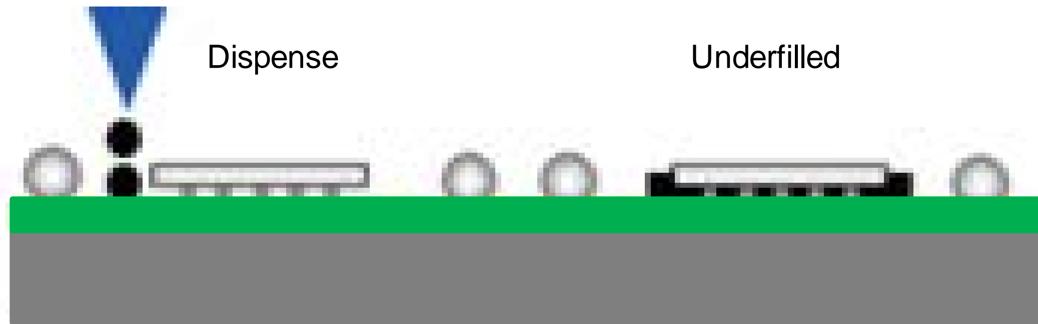
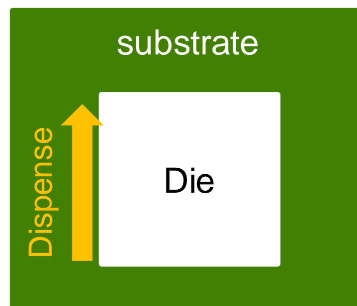
Flip-chip on BGA underfill



Underfill process: side view



Top view

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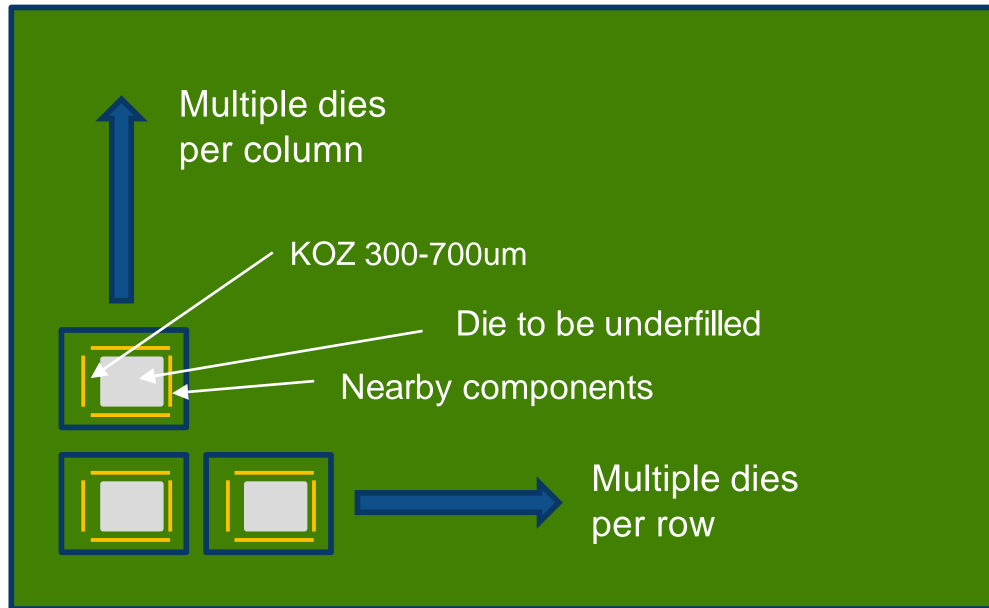
Chip level underfill criteria: KOZ 300-700um at UPH 4000-7000



Chip level underfill with die and components densely populated

400-900 units per board

Throughput 4000-7000 unit per hour

KOZ 1-2mm in 2015, 700um in 2016, 300-500 in 2016-2017

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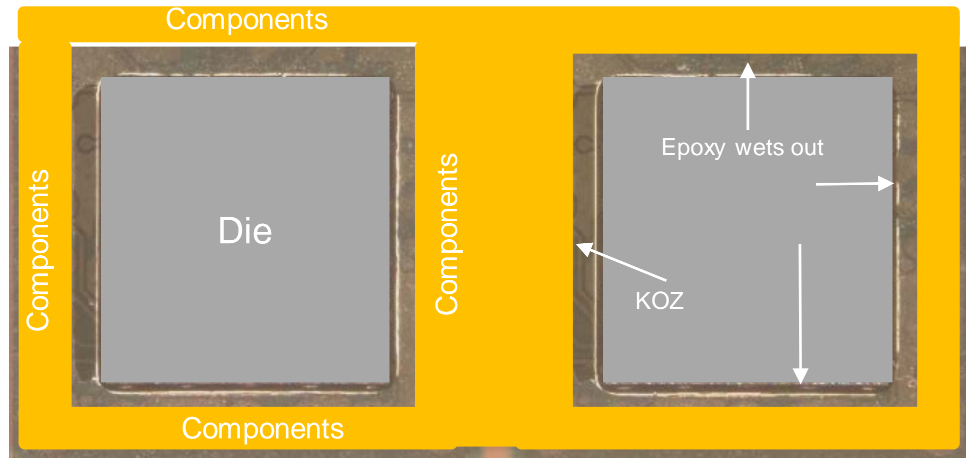
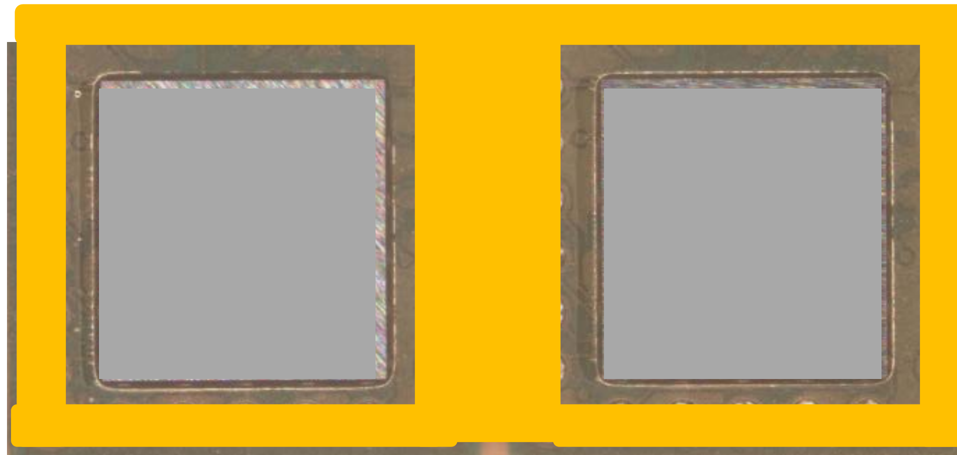
Chip level underfill solution: KOZ 300-500um at UPH 4000-7000



(a) KOZ=300-700um after dispense



(b) Epoxy cured by heat

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Advanced dispenser solution

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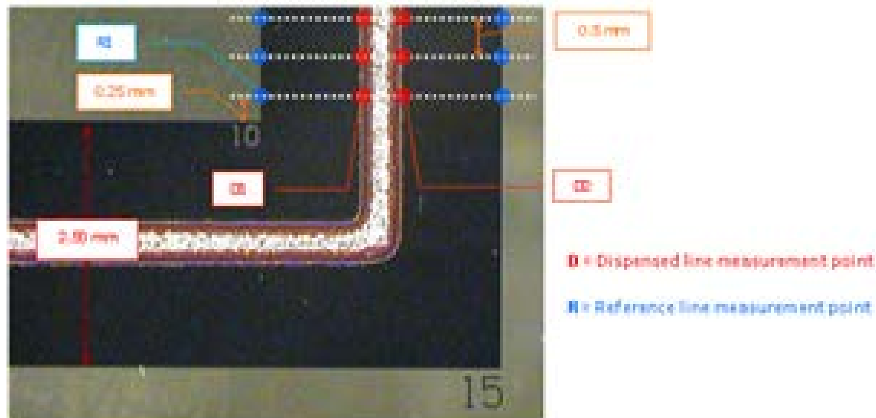
Advanced dispenser solution: high accuracy platform

- A dispenser platform achieved the high accuracy.
  - X and Y axis wet dispense accuracy ±40µm @ 3σ
- To verify the accuracy, placement error was measured as the positional offset between the center of the reference line and the center of the dispensed lines.



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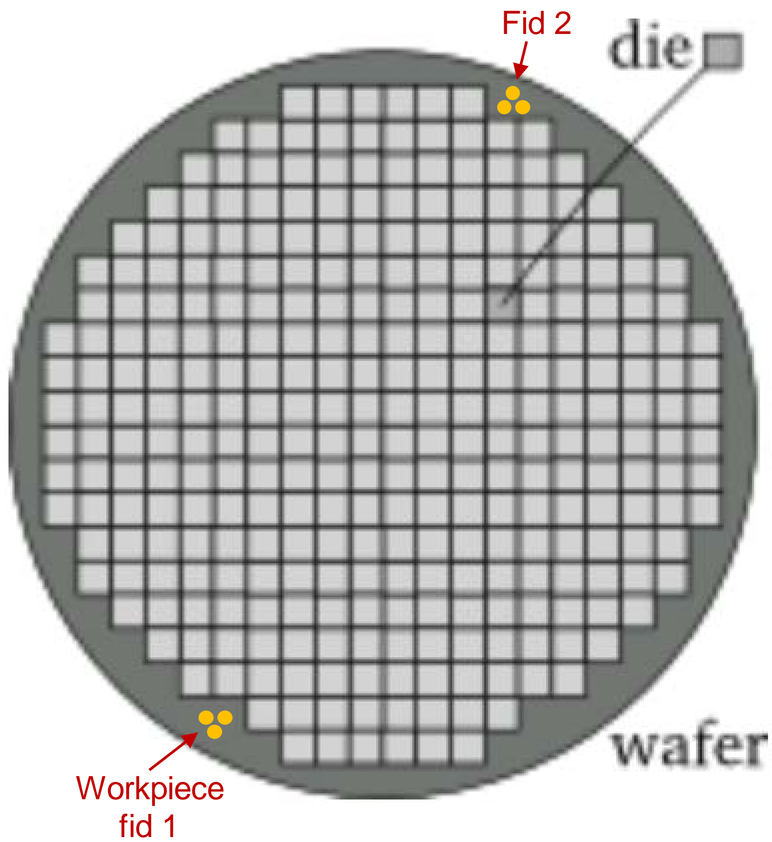
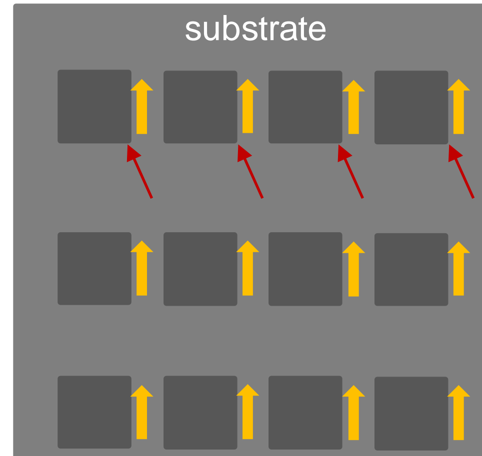
Advanced dispenser solution: vision to locate each die





Pattern:
die
Corner fid 1

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Advanced dispenser solution: thin stream jetting

- 50 µg dot with 1.6 specific gravity: 400-µm diameter sphere in air.
- 16 µg dot: 270-µm diameter sphere.
- A newly developed jetting applicator achieved the small dot size and in-air width with;
  - New jet-cartridge design
  - PZT actuator
  - Actuation velocity
  - Stroke control
  - High firing frequency 500-800Hz
- 8 µg dot: 500um KOZ
- 3 µg dot: 400um KOZ

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Summary

- Backgrounds of underfill process
- Underfill for chip-on-wafer and chip-on-BGA
- Challenge and fail/pass criteria: small KOZ, high UPH
- Solution launched in production line
  - The platform achieved ±40μm @ 3σ in X and Y axis accuracy
  - The applicator demonstrated small dot dispensing to achieve sub-500um KOZ
  - Higher jetting frequency 500-800 Hz to maintain high UPH 4000-7000
  - The software contributed to applicator operation, vision detection, features for high UPH

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Acknowledgement

Akira Morita

"*Underfill dispensing for Chip-on-wafer*", Semicon China CSTIC 2017 Symposium

By Akira Morita, Weiwei Gu & Brian Chung

Focus on dispensing small dots through 350um gap between chips

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