Design of Filled One Step Chip Attach Materials (OSCA) for Conventional Mass Reflow Processing: Rheology Considerations for Jet Dispensing and Die Placement

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Outline

Introduction

- Conventional Flip Chip Assembly Process
- One Step Chip Attach Process & Materials (OSCA)

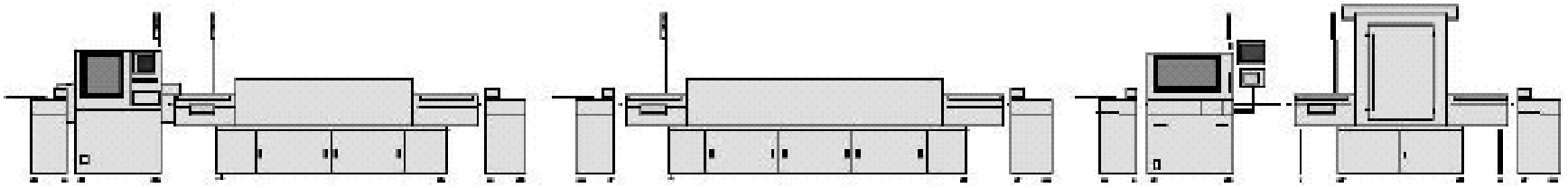
OSCA Materials for Reflow Processing (OSCA-R)

- Design for Dispensing & Die Placement - Fillers
- Copper Pillar Test Vehicle
- Reflow Processing
- Assembly by Conventional Reflow

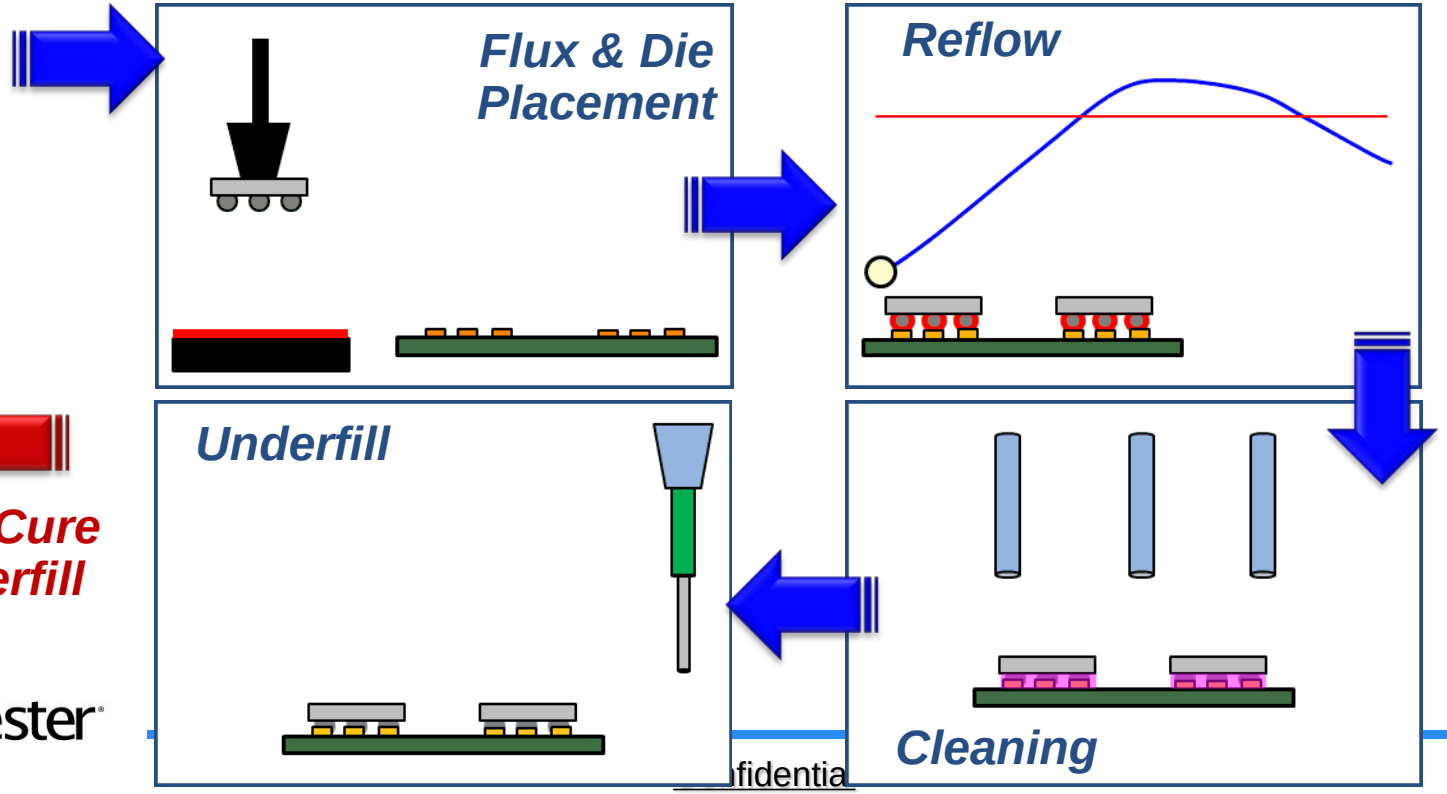
Summary & Conclusions

Acknowledgements

Conventional Flip Chip Assembly Process

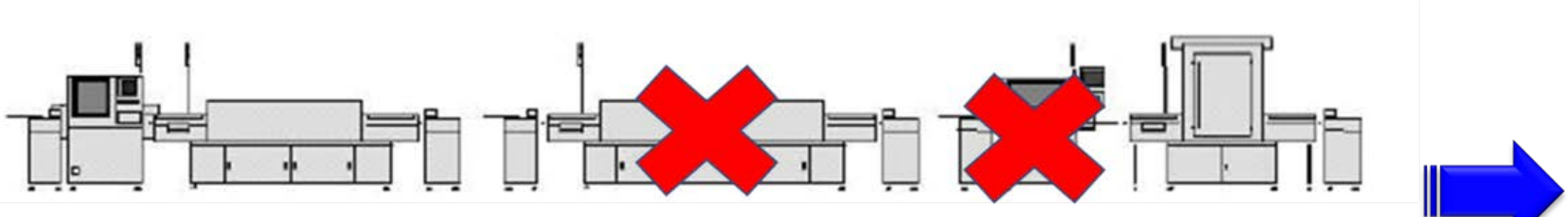


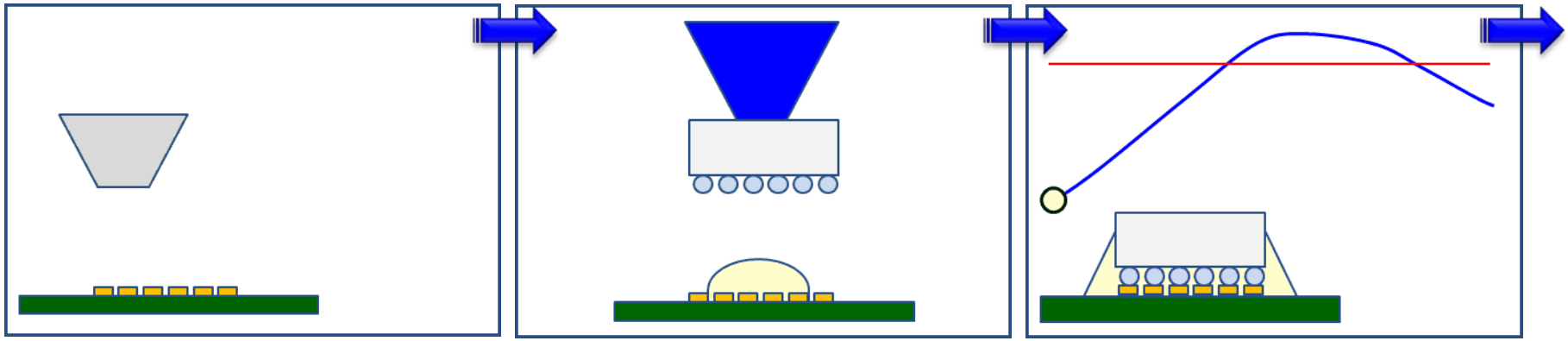
Flux / Chip Place | Reflow | De-flux | Underfill | Post Cure



Advantages of OSCA Materials & Process

Process Simplification + Throughput

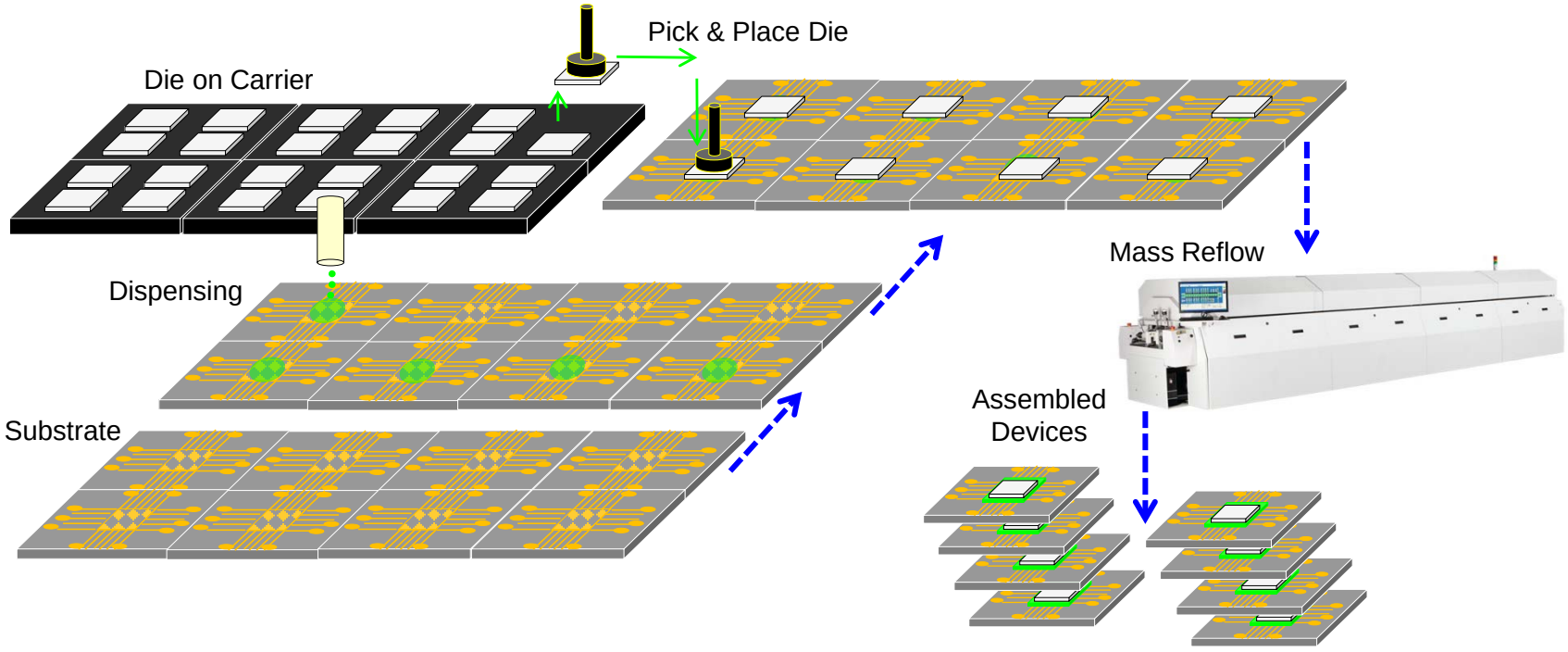




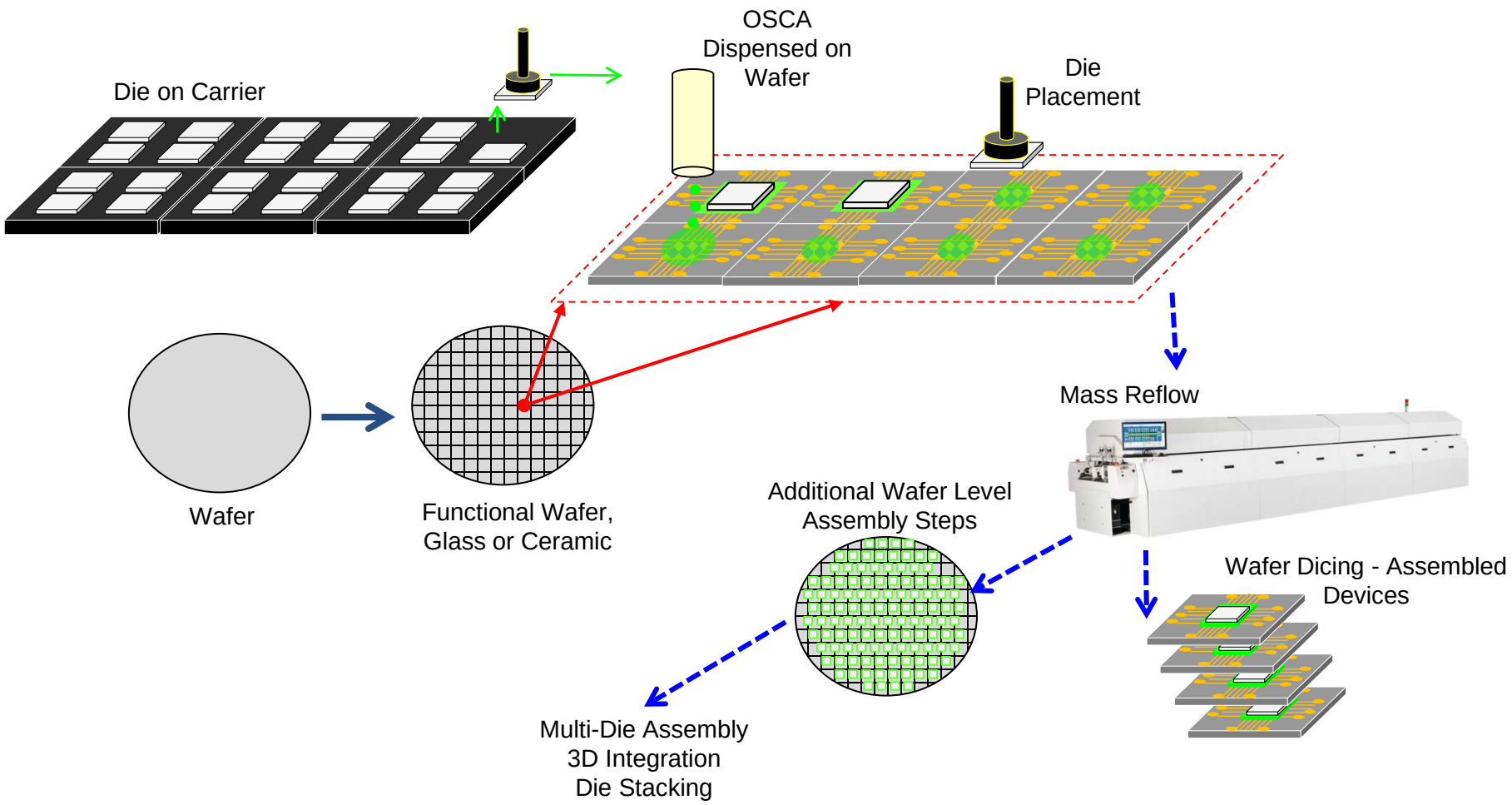
Dispense OSCA-R | *Die Placement* | *Conventional Reflow Processing*

Assembly Using OSCA-R Materials

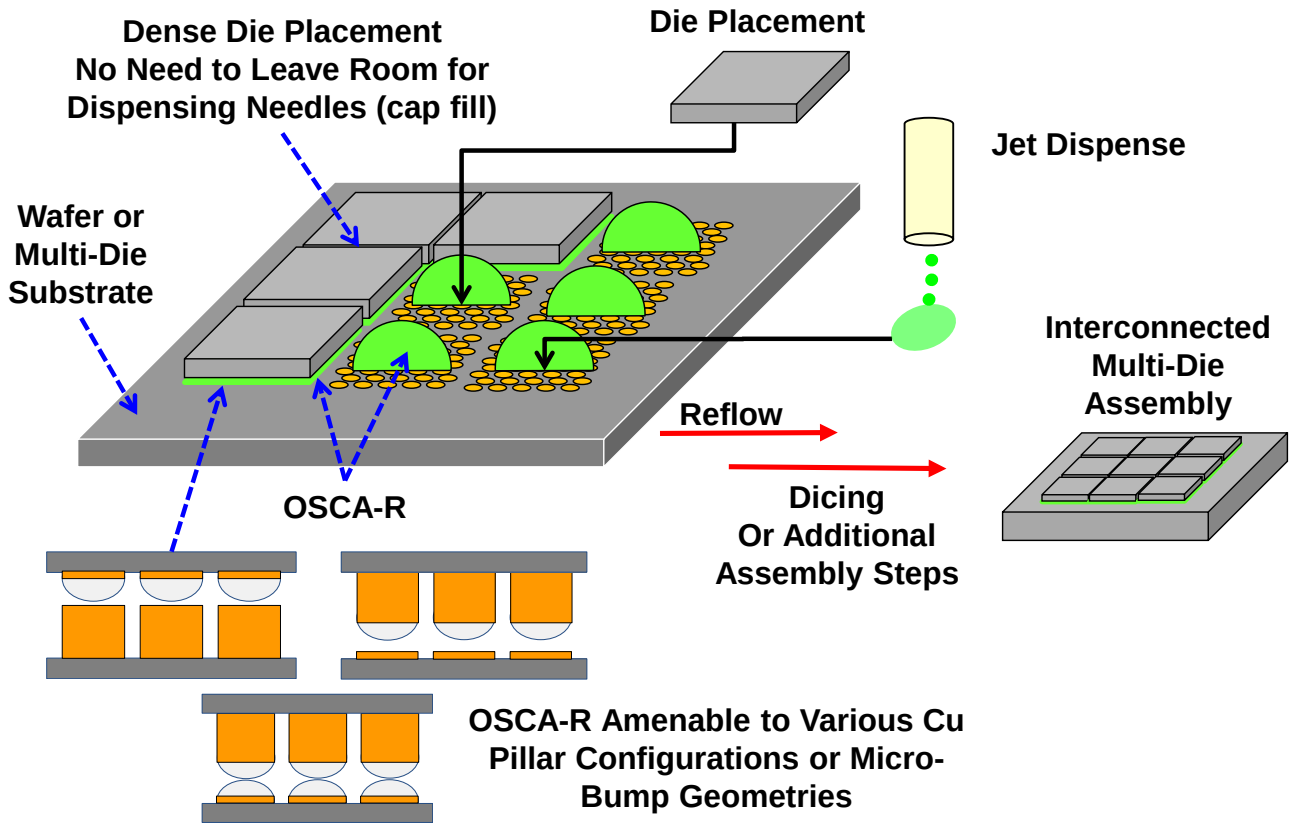
Reduced complexity and increase throughput



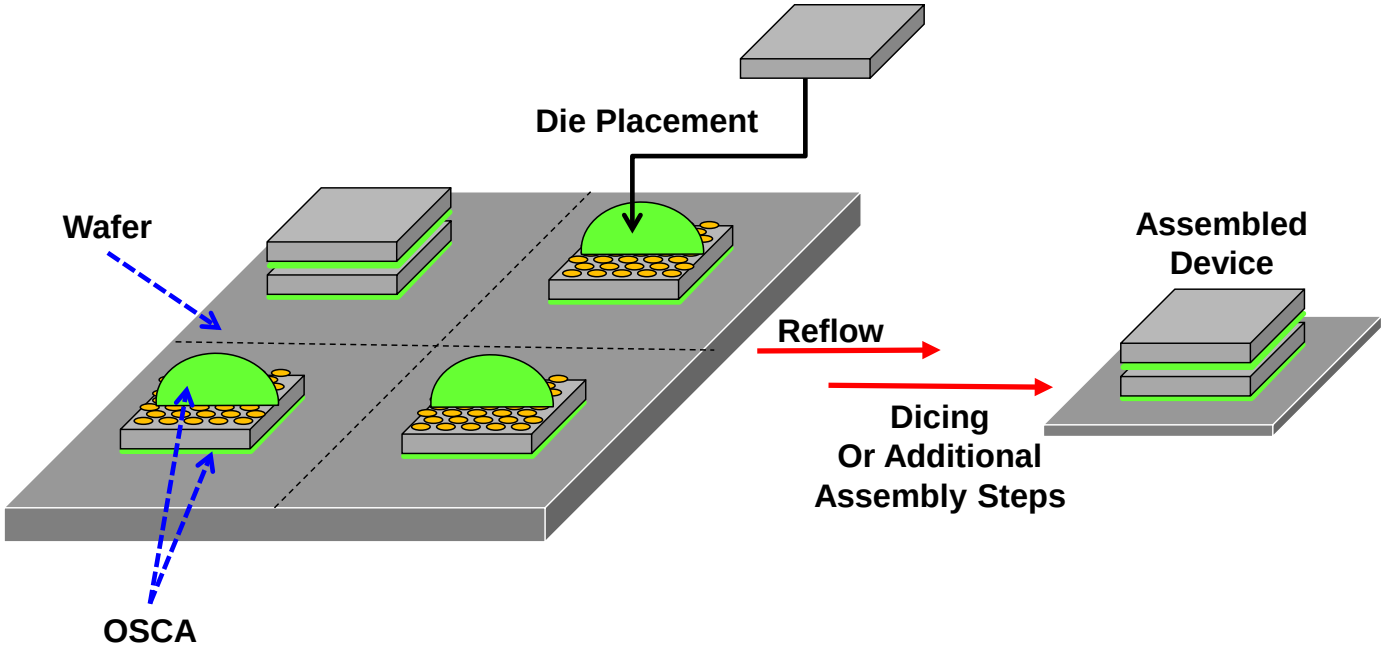
Assembly Using OSCA-R



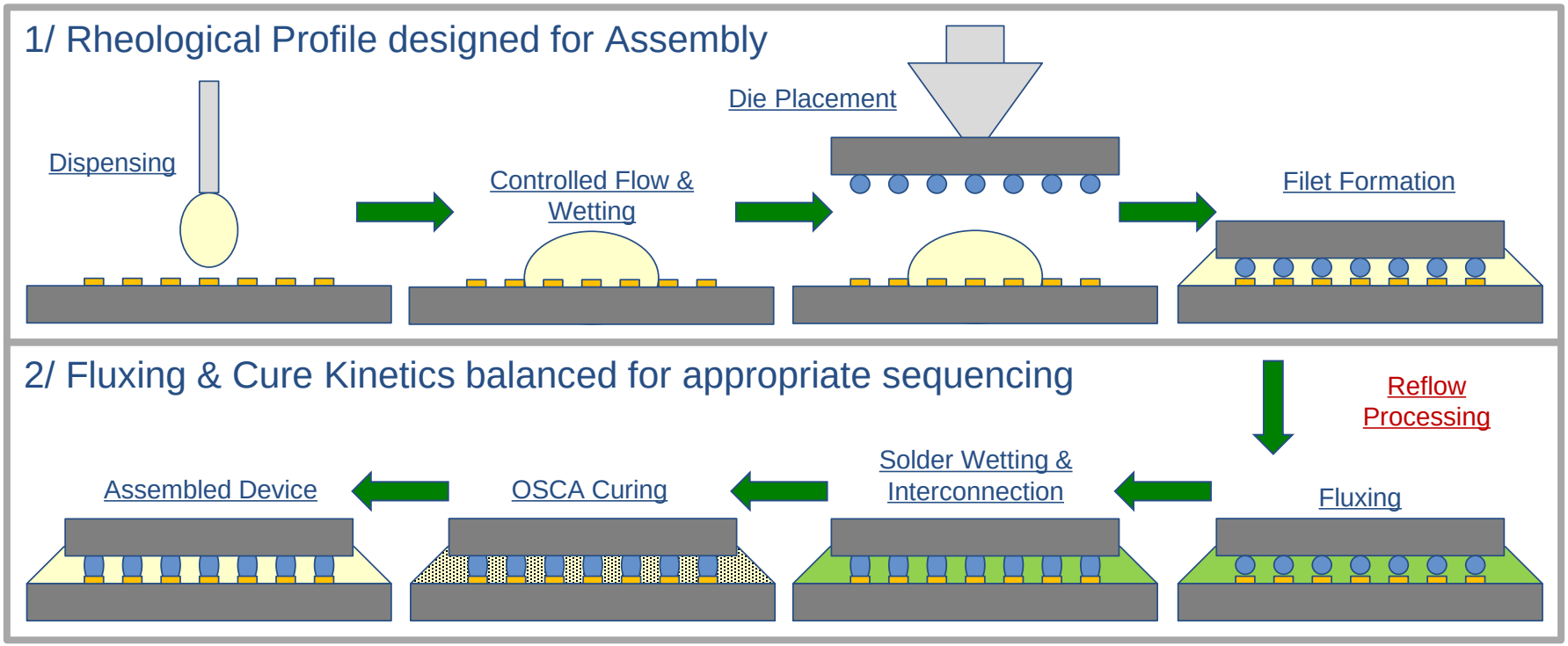
Multi-Die Assemblies Using OSCA-R



Die Stack Assembly Using OSCA-R



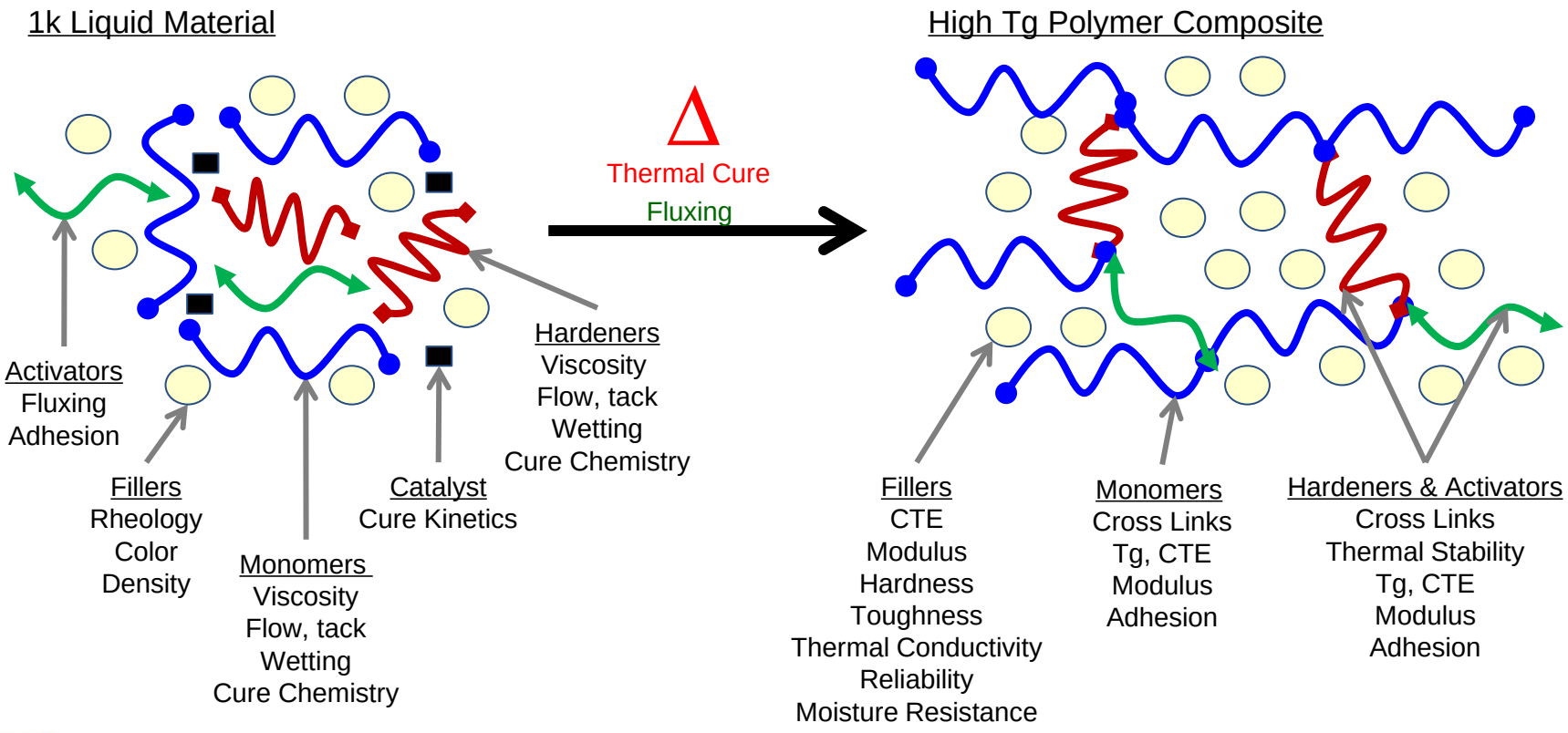
One Step Chip Attach Process & Materials



- Key formulation design considerations for OSCA-R materials
  - Rheology/flow for dispensing and die placement
  - Balance of fluxing & cure chemistry during reflow processing
  - Final cured properties, interconnection and reliability

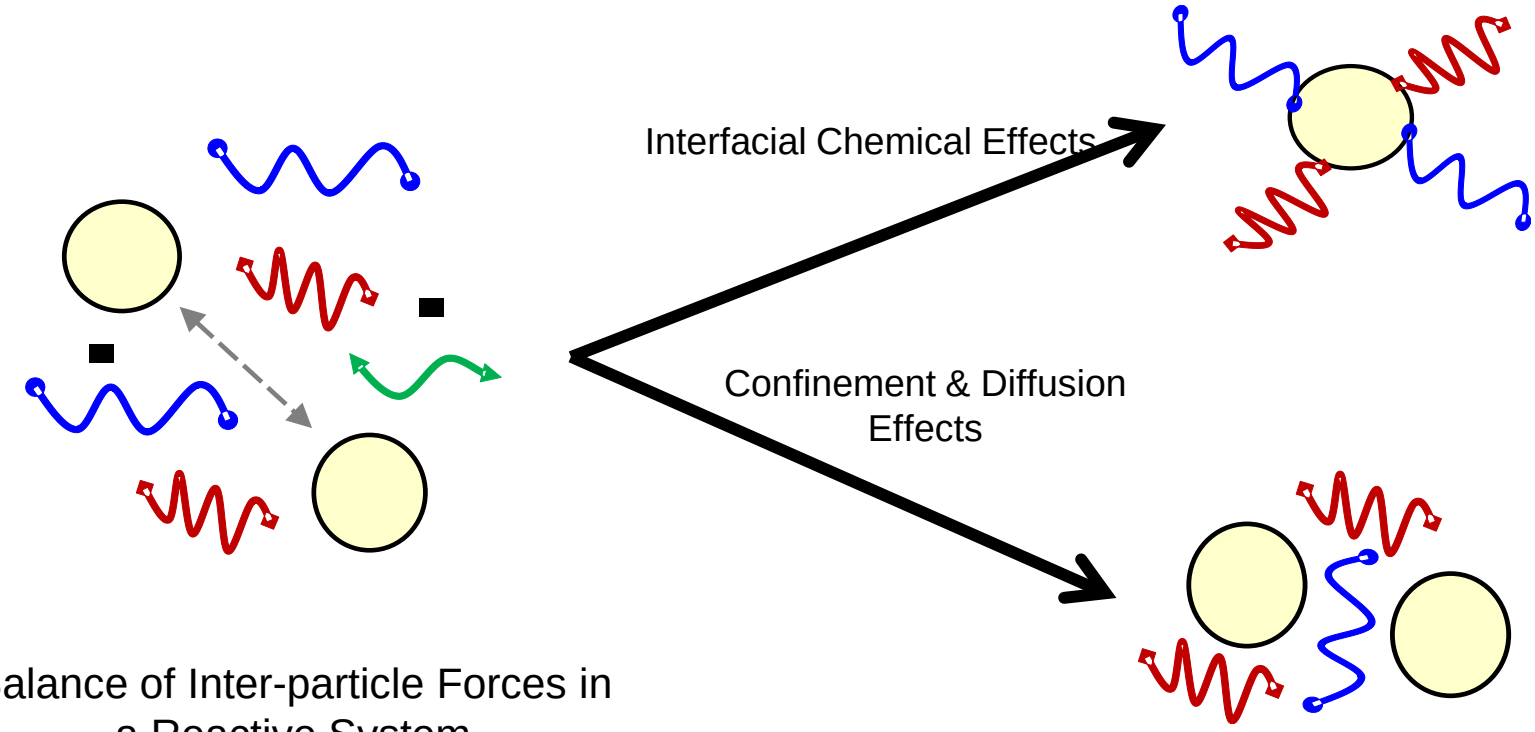
OSCA-R Material Design

- OSCA-R is a multi functional reactive mixture that fluxes and then thermally cures to a high performance thermoset polymer composite during reflow processing



OSCA-R Design – Flow Fluxing & Cure

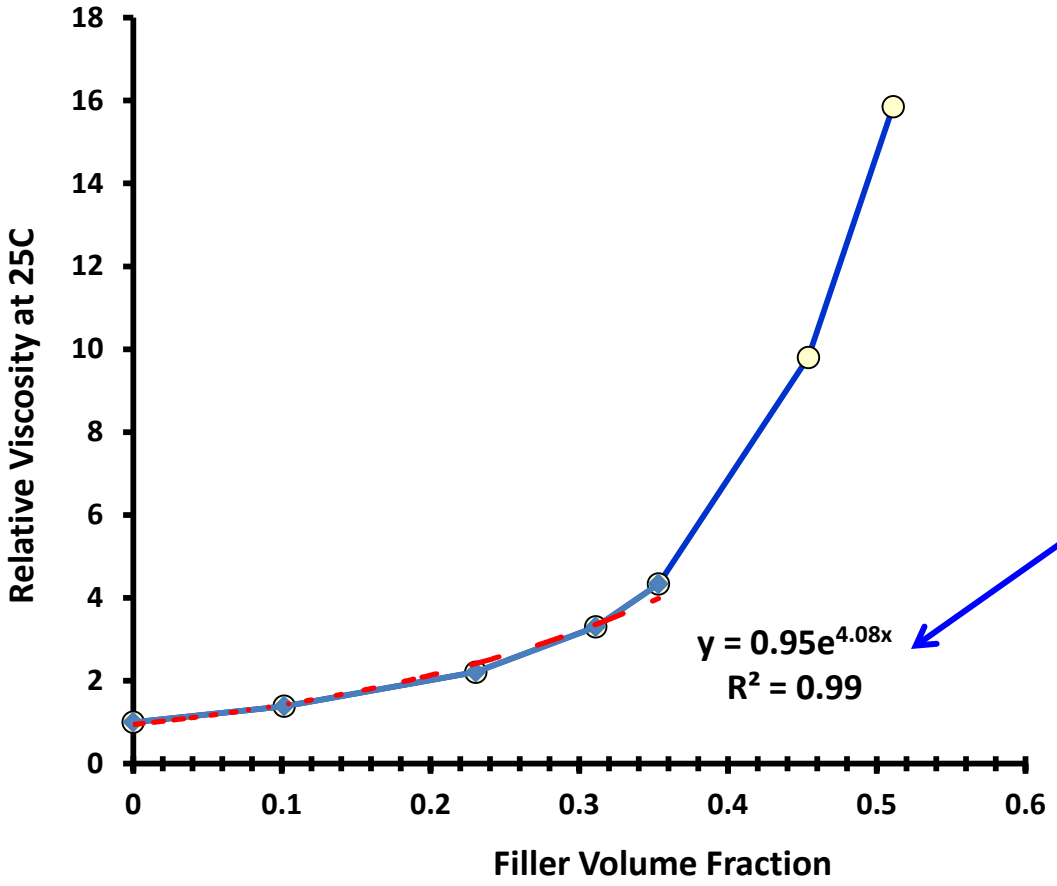
- Particle effects on flow and cure
  - Understand chemical and physical interactions
  - Anticipate and take advantage of for material design



Balance of Inter-particle Forces in a Reactive System

OSCA-R Flow – Filler Loading

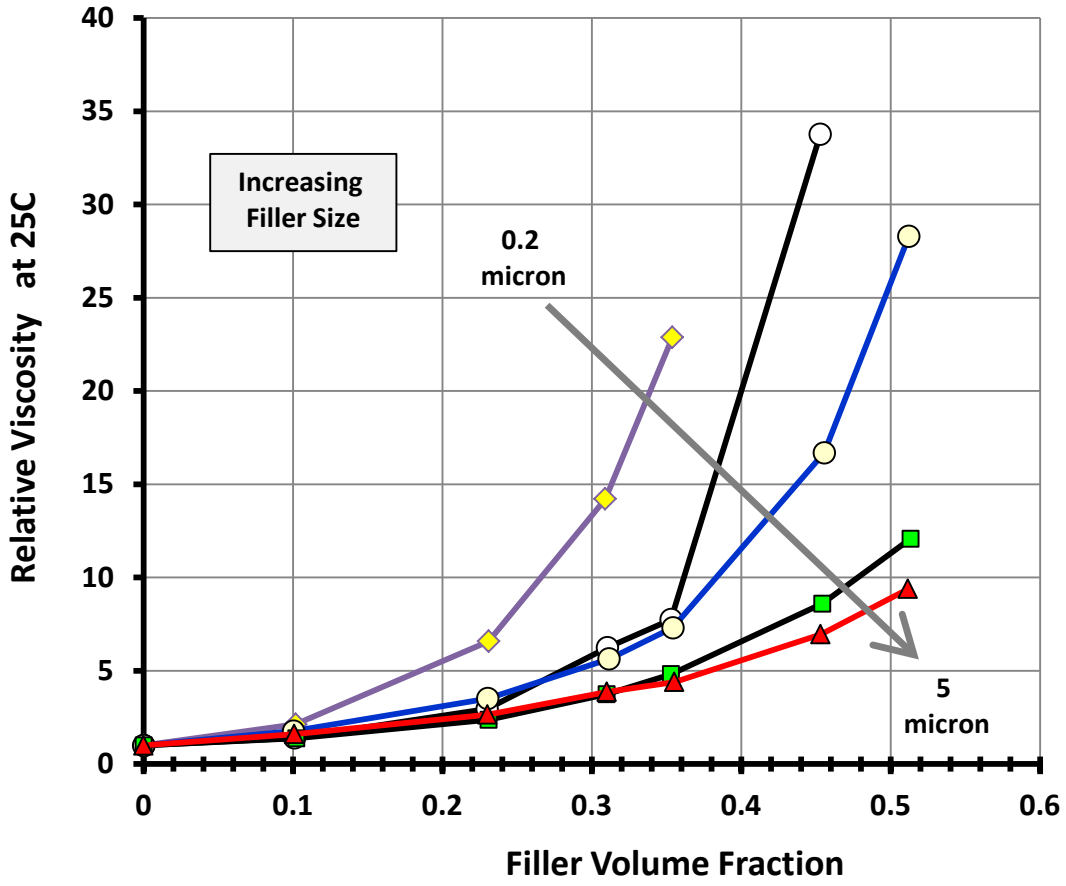
- First step in filled system design – understand loading response



Use semi-empirical modeling to help design and select fillers and resins for best flow response

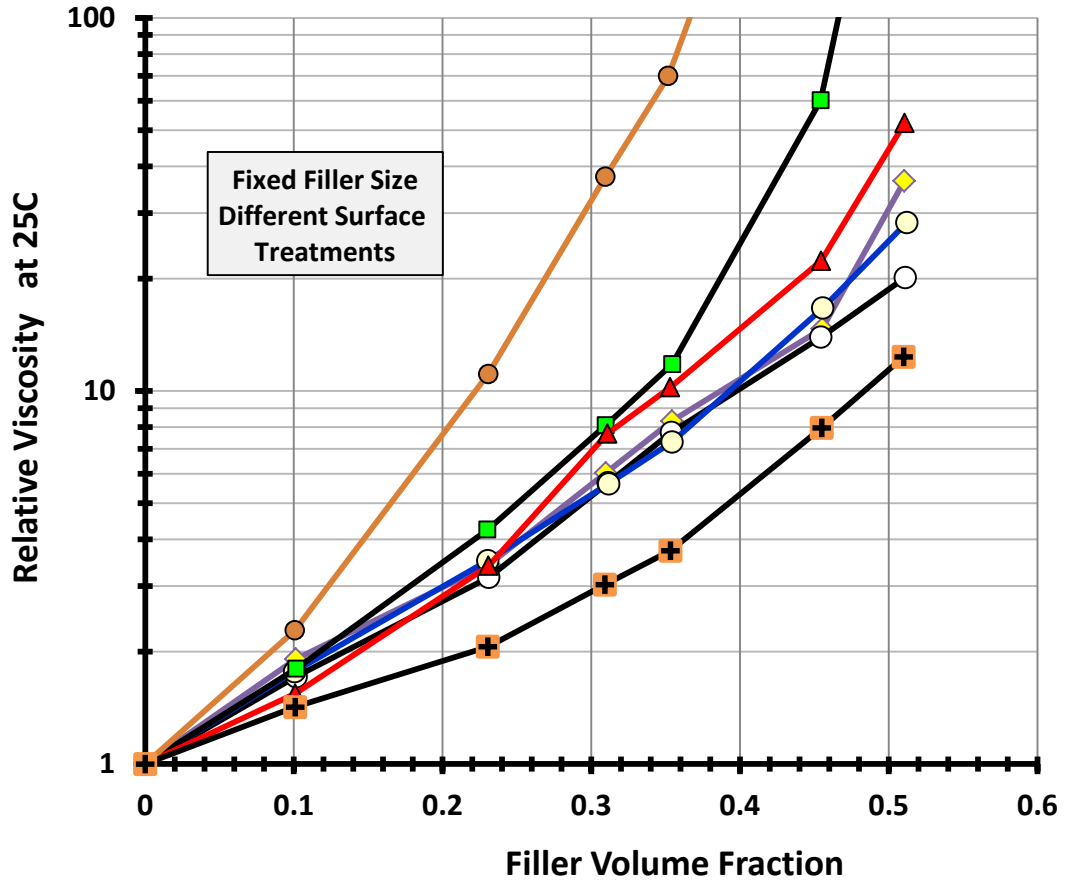
OSCA-R Flow – Filler Size

- Second step in filled system design – understand filler size response
  - Sub micron fillers required for fine pitch assemblies



OSCA-R Flow – Filler Interface Design

- Final step for filled system design – particle interface and interactions with resin



Dispensing

OSCA-R materials designed for use with different dispense technologies

Time-Pressure

Time-Pressure

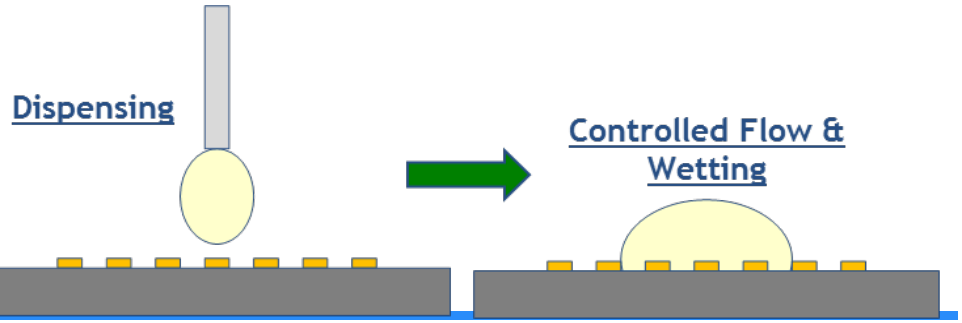
Auger

PDP - Auger

Jet

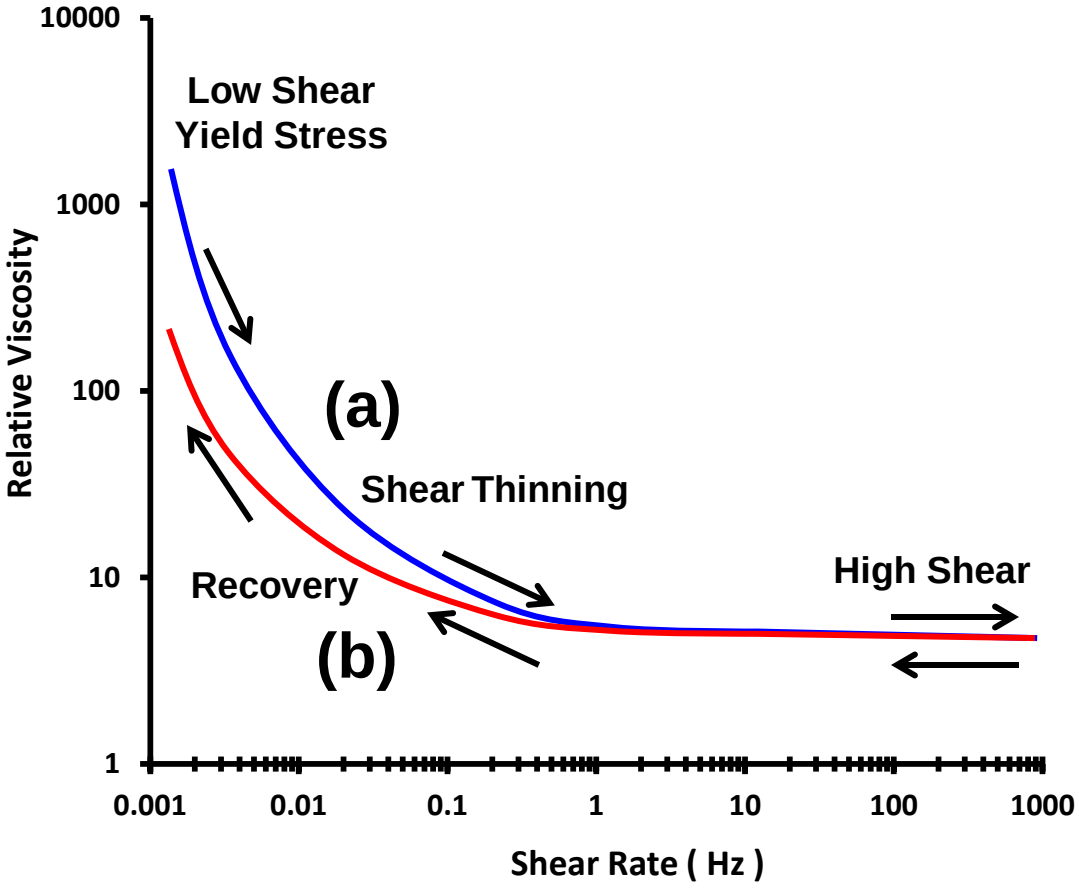
SmartStream™ NanoShot™

Jet Dispense



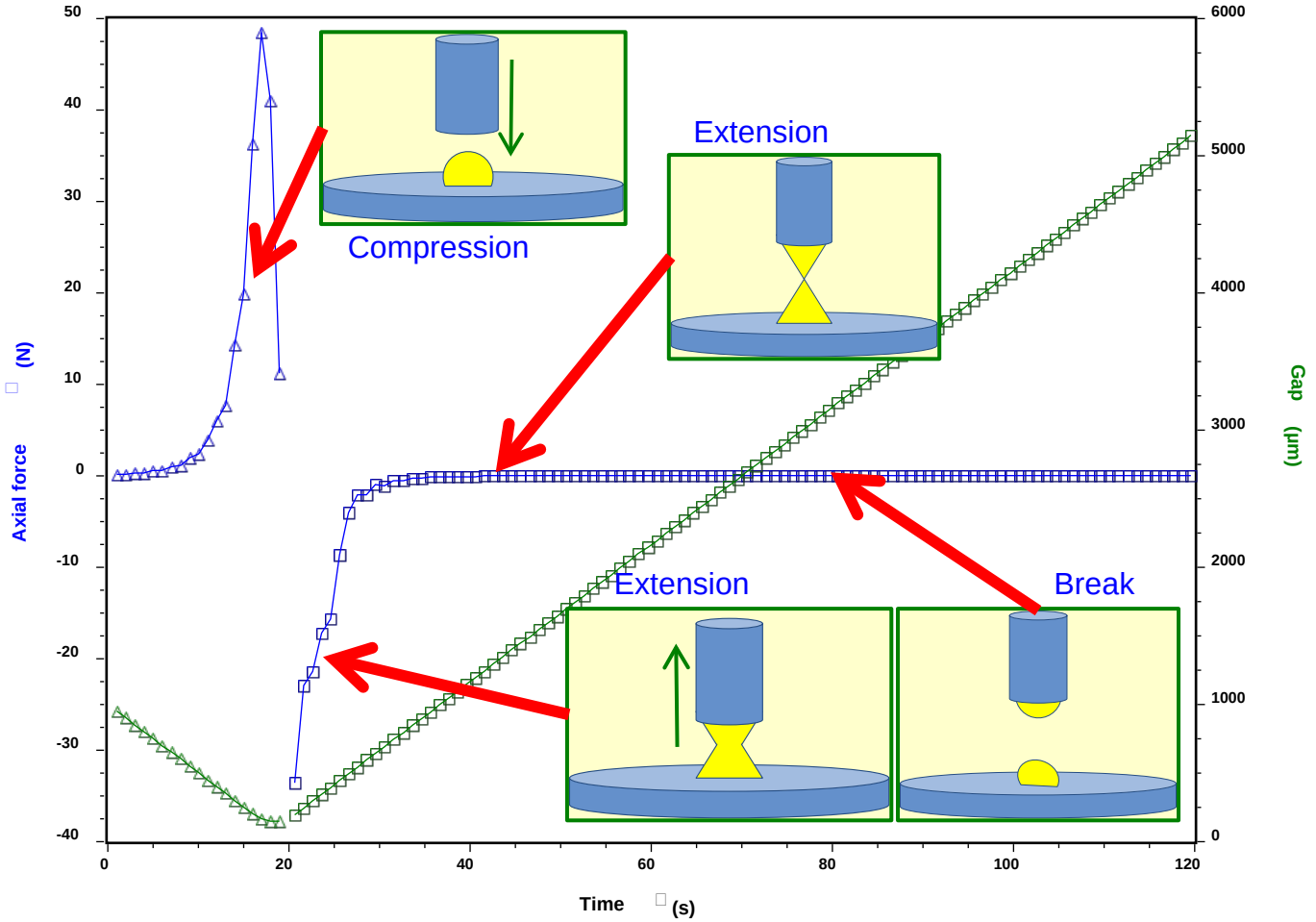
OSCA-R Flow – Shear Rate Response

- Design a non-Newtonian rheology response for dispensing and placement



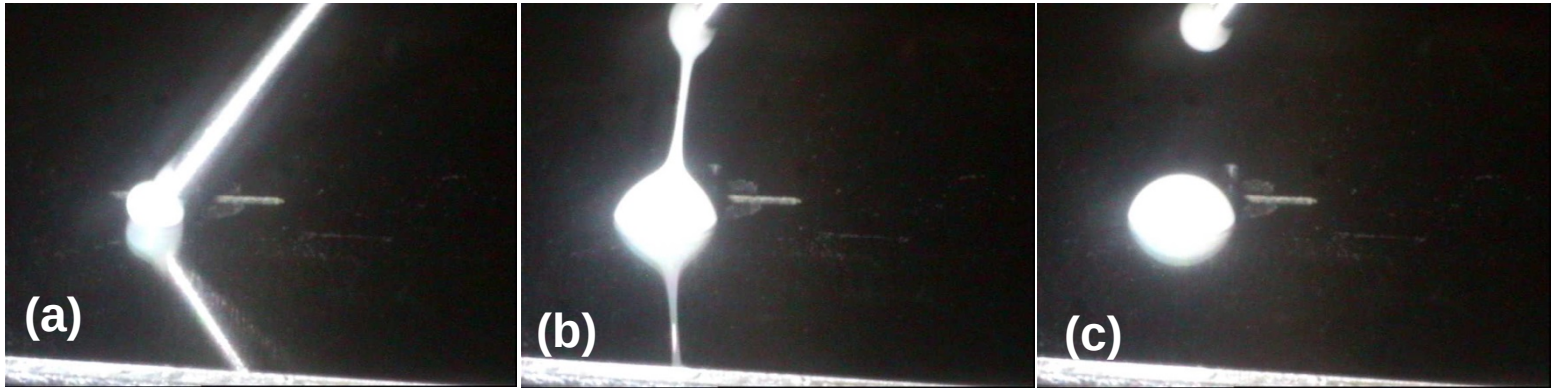
OSCA-R Flow – Under Compression and Extension

- Flow under compression and tension → Placement and dispense



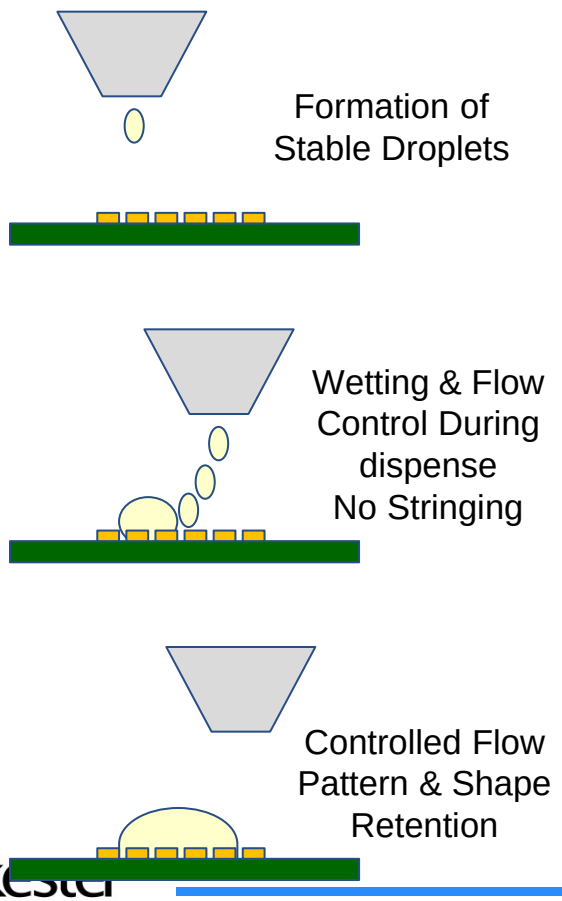
OSCA-R Design for Dispense

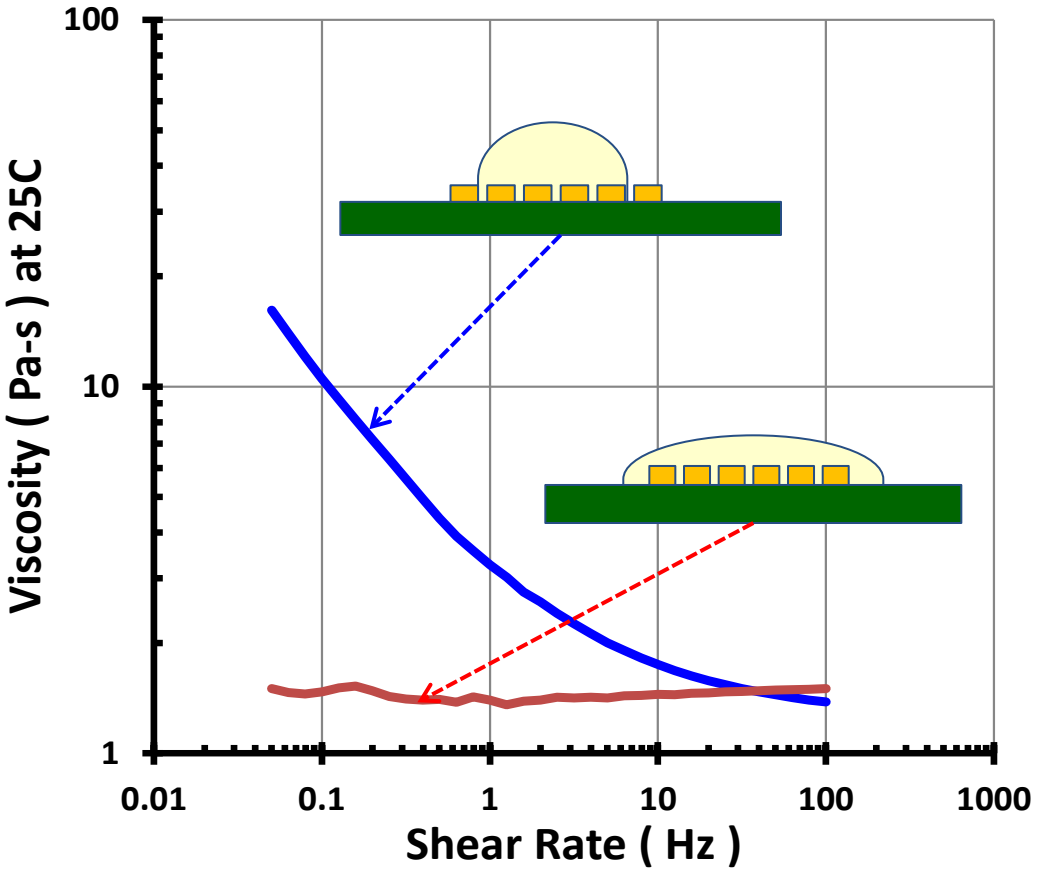
- Filled system design – avoid “stringing” and enable clean release during jet dispensing



OSCA-R Flow - Dispensing

Fluids with shear thinning / yield stress behavior meet patterning & flow control CTQs

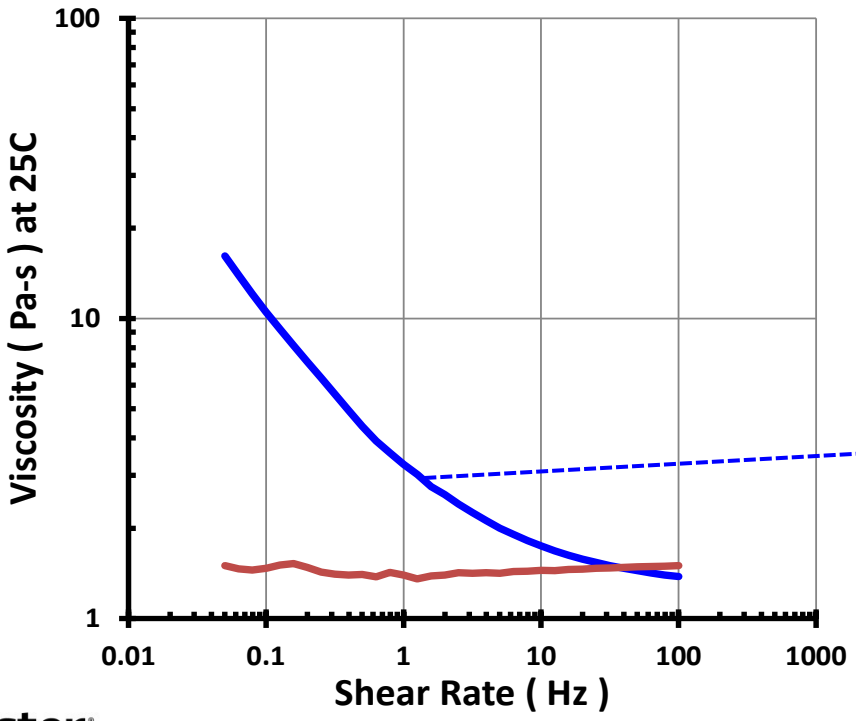




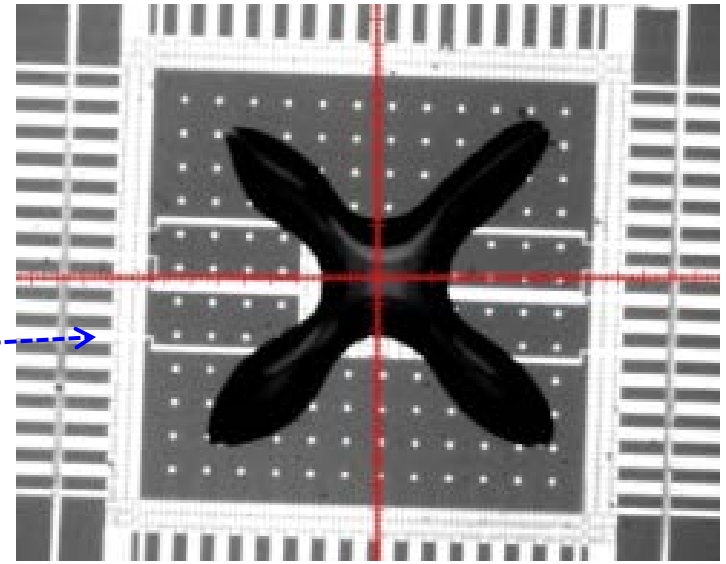
OSCA-R Flow - Dispensing

OSCA-R materials have good jet dispensing characteristics and pattern retention

Controlled flow keeps materials out of “no-go” zones and avoids bleed out



OSCA-R Dispensed on Test Vehicle

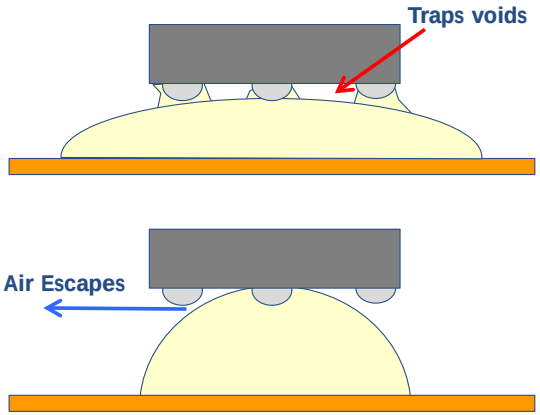


OSCA-R Flow - Die Placement

OSCA-R materials designed to overcome key placement challenges

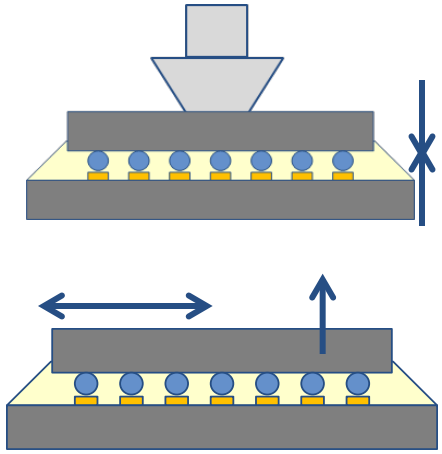
- Flow properties enable dispense pattern and void elimination

Void Elimination



- Flow behavior during die placement under compression can complicate accurate die placement

Rebound (viscoelasticity)



OSCA-R Flow - Die Placement

OSCA-R materials designed to overcome key placement challenges and to be compatible with common placement technologies

R&D Bonder

Board Level Assembly

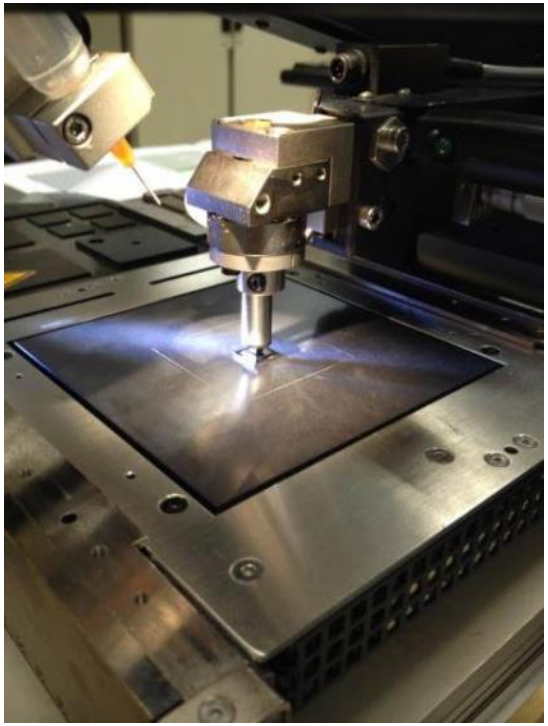
Flip Chip Assembly

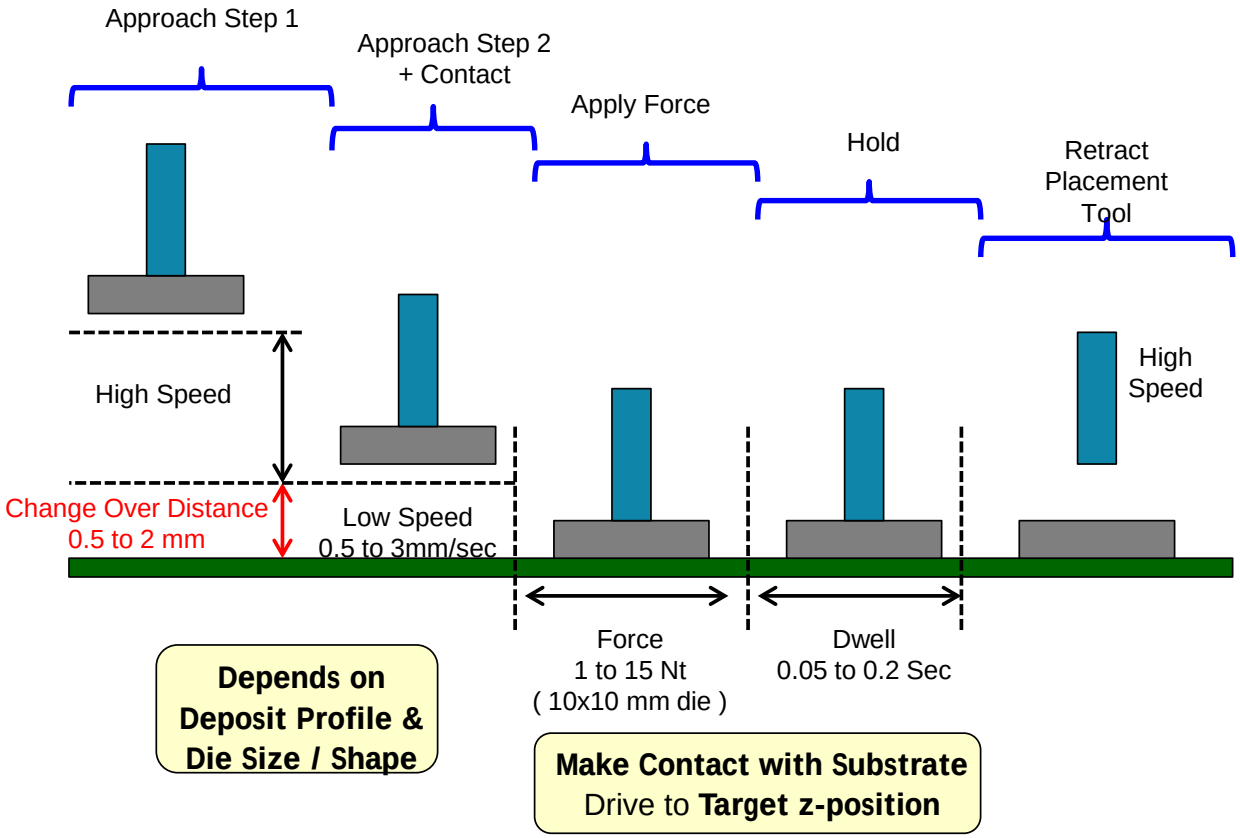
Thermo Compression Bonding

OSCA-R Flow - Die Placement

Finetech die bonder system

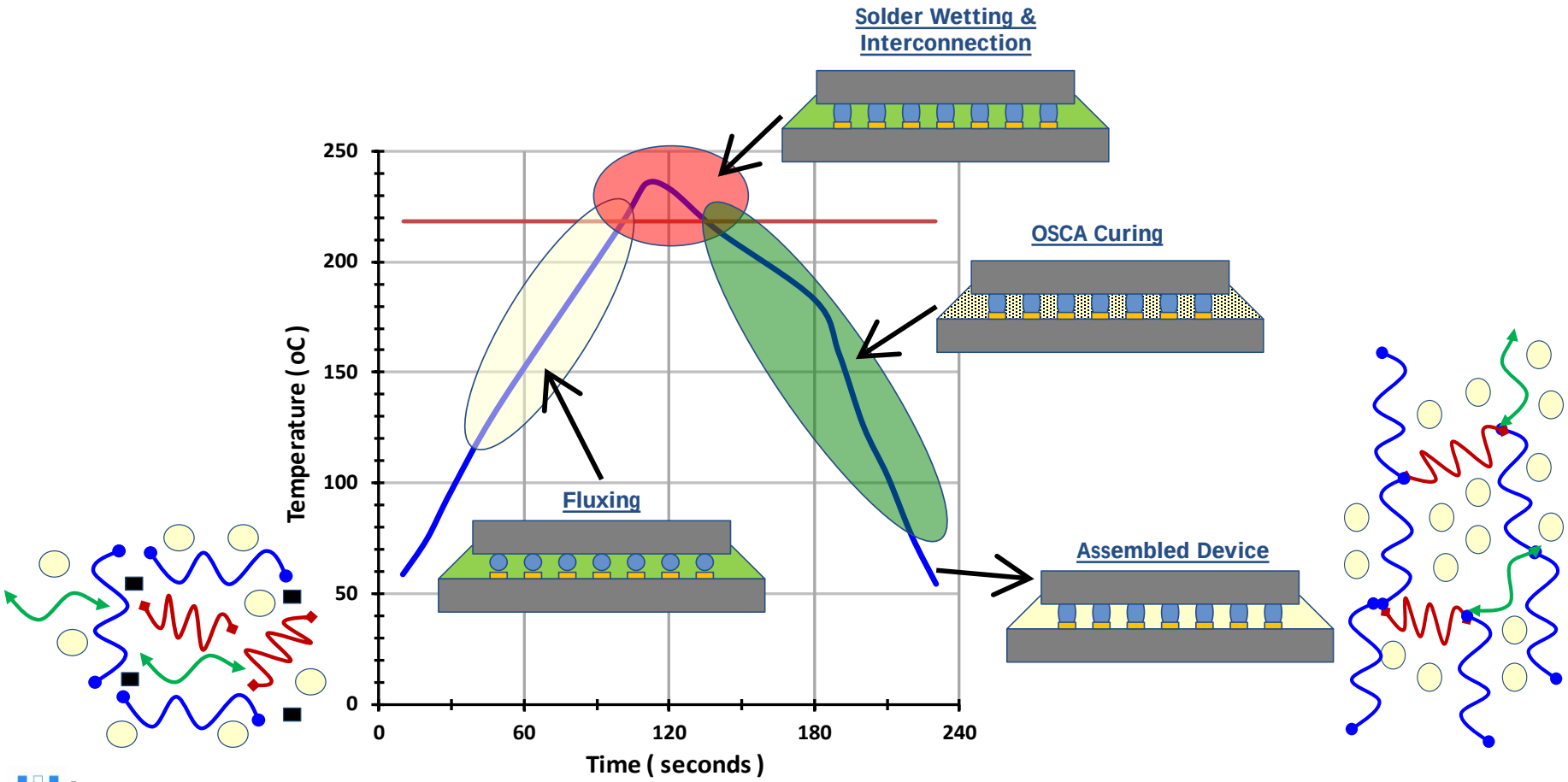
- Multi step placement procedure ensures die contact, and flow





OSCA-R Reflow Processing

Timing kinetics of fluxing, solder melting, interconnection and cure

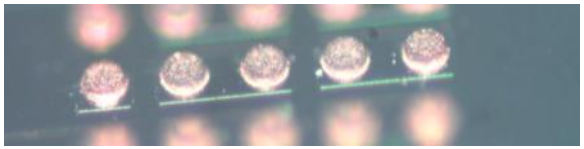


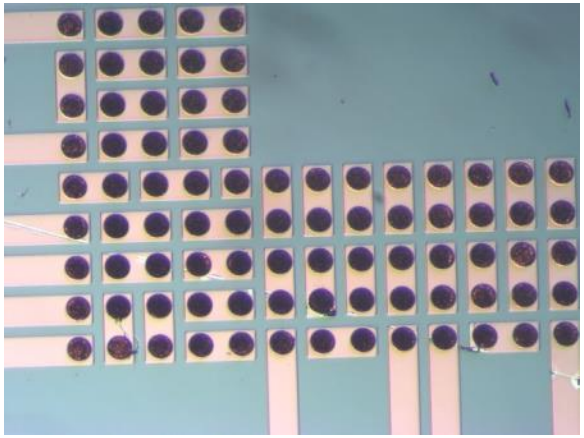
Coper Pillar Test Vehicle

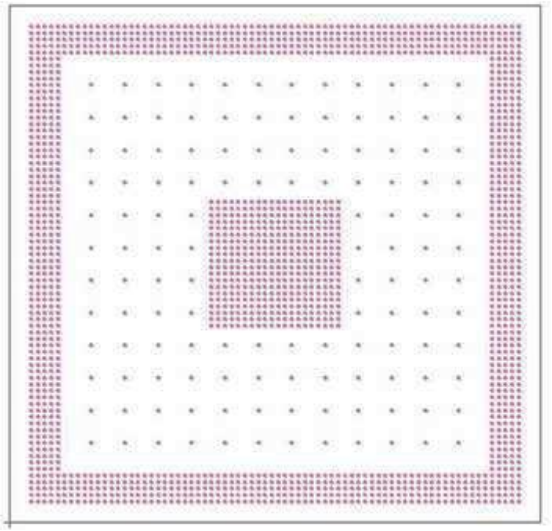
Cu pillar test vehicle used for OSCA-R evaluations

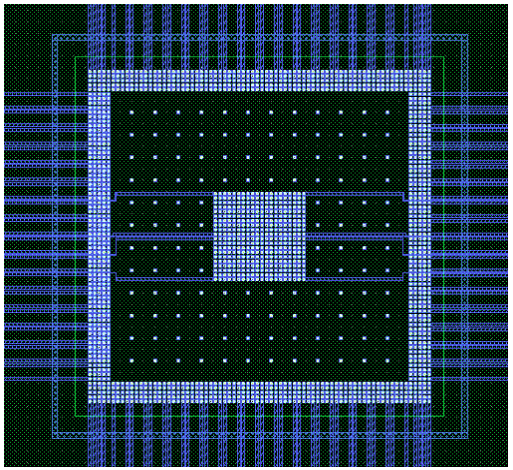
Wafer thickness = 0.75mm
Die size = 6.35x 6.35mm.
Two daisy chained arrays
Central Array 20x 20 bumps (400)
Perimeter Array is 5x 70 bumps per side (1300)
128 interstitial bumps

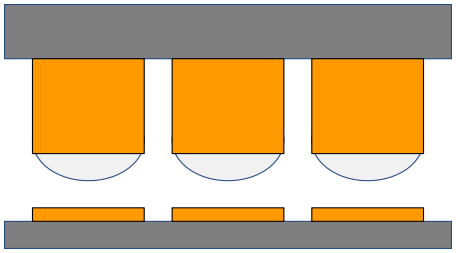
Pitch = 80 microns
Cu Pillar Height = Diameter = 40 micron
10 micron SnAg cap on pillars
Cu Pad Diameter = 40 microns
Cu Pad Height = 10 micron







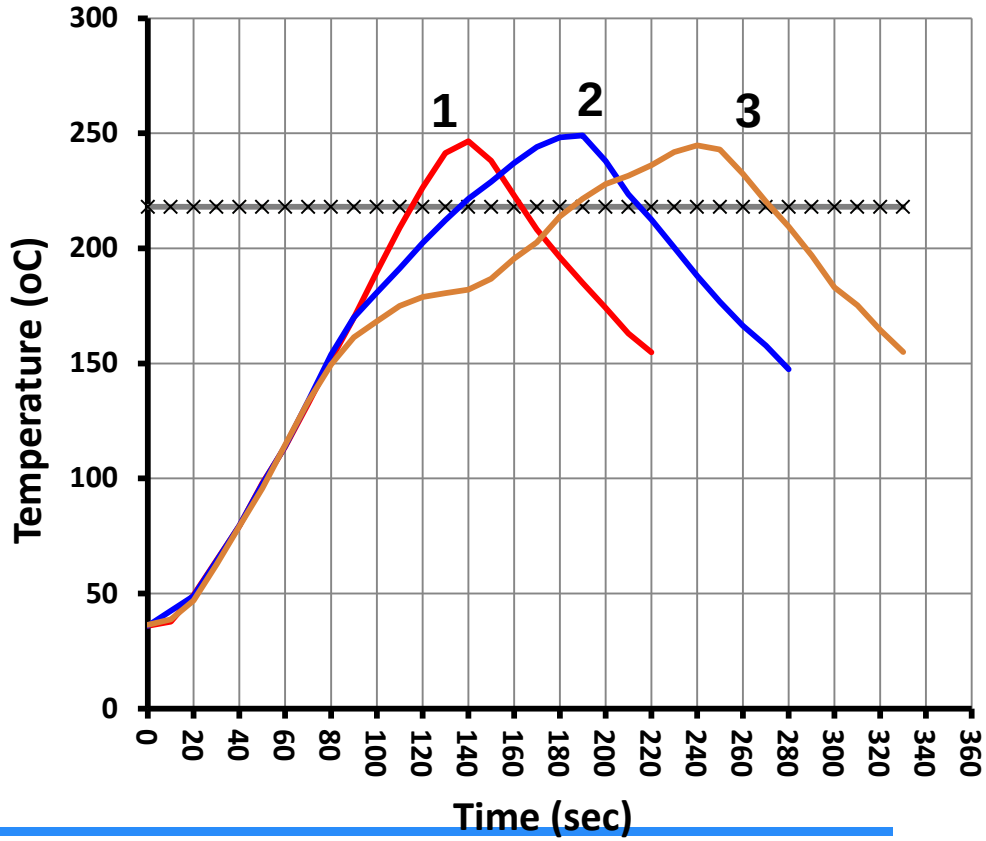




OSCA-R Reflow Processing

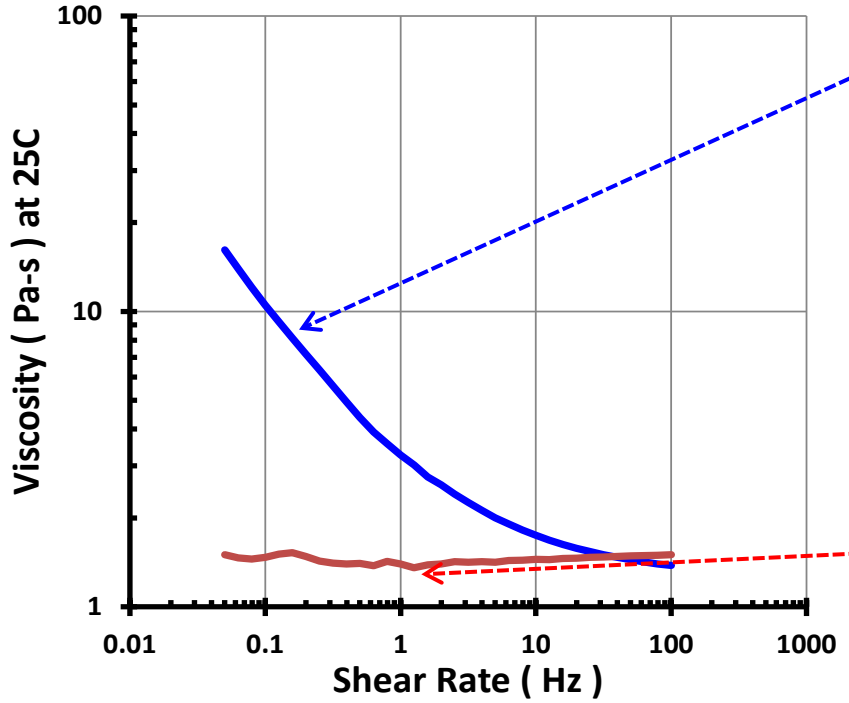
Examples of reflow profiles used to assemble devices with OSCA-R materials

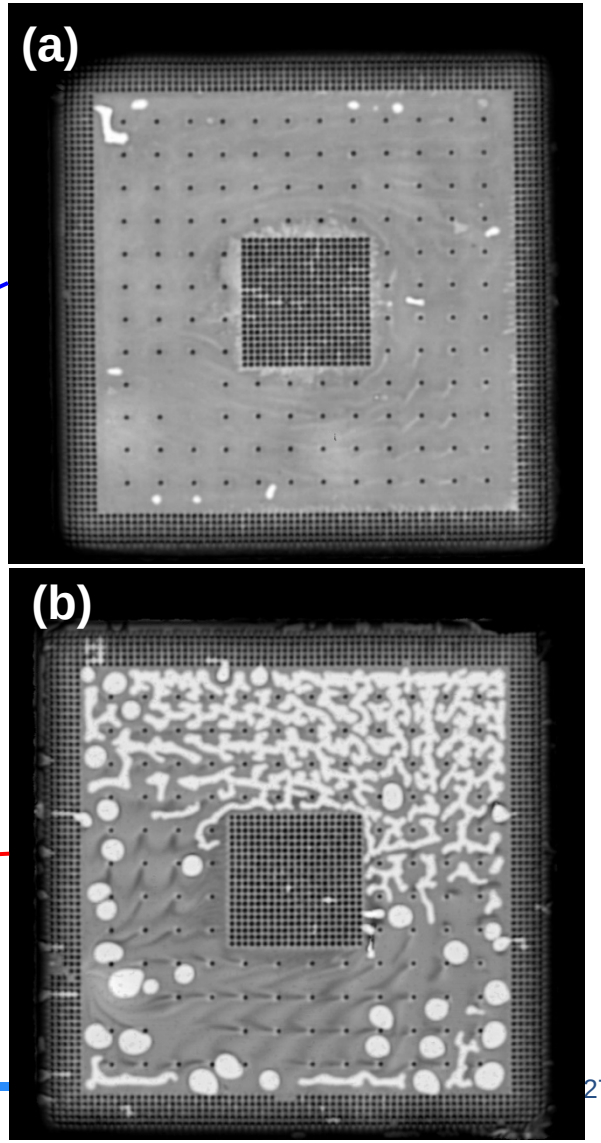
- Range of profiles for different assembly applications



OSCA-R Assembled Devices

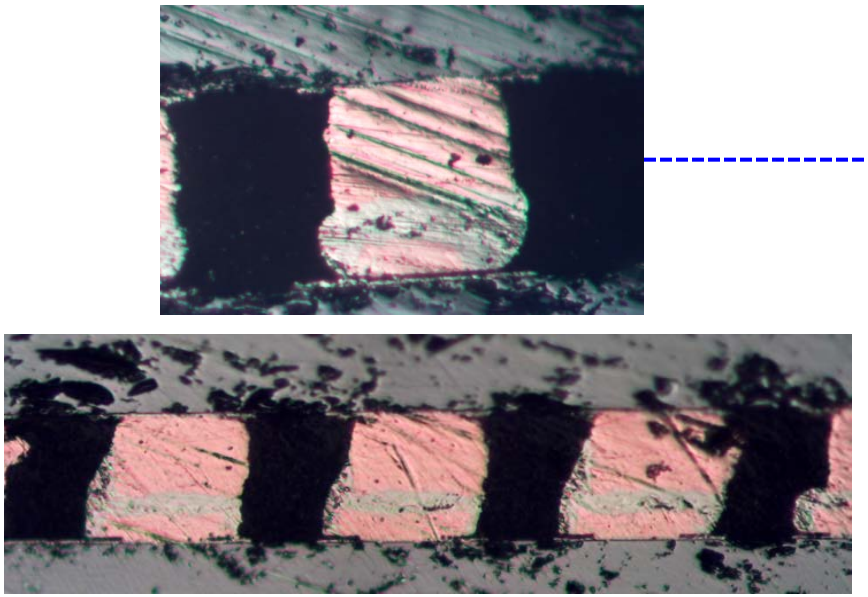
Illustration of relationship between placement voids and ORCA-R rheology design

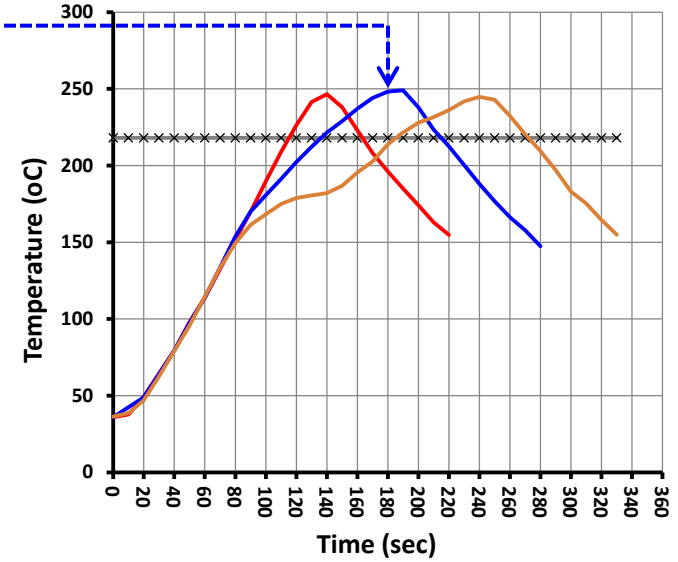




OSCA-R Assembled Devices

Successful assembly of devices with copper pillar features using conventional reflow processing and OSCA-R materials





Summary & Conclusions

One Step Chip Attach (OSCA-R) materials can be used to assemble devices with copper pillar features using convection or conduction mass reflow

- Single die devices assembled in this work
- Can be extended to wafer level
- Can be used for 3D assembly
- Device density increase, close placement
- Approach reduces complexity of manufacturing with respect to conventional processing
- Higher throughput with use existing processing equipment

Summary & Conclusions

Approaches to overcoming the key technical challenges presented

- Systematic studies of soldering, rheology cure kinetics and used to design OSCA-R materials for dispensing and successful assembly
- Die and substrate size, configuration and type are integral considerations for OSCA-R materials and processing

Process integration is key to enabling OSCA-R materials

- Chemistry matched to desired reflow processing
- Rheology adjusted for dispensing and die placement process

Thank You for Your Attention

Questions?

Acknowledgements:

Kester Inc. → David Eichstadt, Maulik Shah, Chris Klimaszewski, Jim Lowe, Kal Chokshi

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Sonoscan → Michelle Forbes

OSCA-R Material Properties

- Rheology, viscosity, flow properties tunable for target dispensing/flow during die placement, cure kinetics and thermomechanical properties

Property (method)	Units	A	B	C	D
Filler %	Wt%	40	55	0	40
Filler Size	micron	0.5	0.5		5
Tg (a)	°C	159	125	116	125
CTE-1 (a)	ppm/K	46	36	68	49
CTE-2 (a)	ppm/K	138	117	212	163
ΔH (b)	J/g	235	165	348	212
T-onset (b)	°C	129	118	160	157
T-peak (b)	°C	197	162	204	203
Viscosity(c)	**Pa-s**	**49**	**26**	**2.6**	**6.8**
Viscosity(d)	**Pa-s**	**14**	**40**	**2.6**	**6.7**
STI (e)	**Ratio**	**3.5**	**0.5**	**1.0**	**1.1**
Yield Stress (f)	**Pa**	**2**	**0**	**0**	**0**
Temperature Thinning (g)	**Kelvin**	**2200**	**7300**	**5000**	**6900**

Thermo.
Cure
Flow