Sandia National Laboratories

3D Reversible Interconnect

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LDRD
LABORATORY DIRECTED RESEARCH & DEVELOPMENT
R&D Program

Goal

Develop a characterization system to screen parts to test electrical conductivity and reliability before a permanent flip chip bond.

Background

Ag Nanoparticle Ink

- PVP (polyvinylpyrrolidone) coated silver nanoparticle suspended in ethylene glycol
- Viscosity: 50-200 cP
- Nanoparticle size: 50 nm
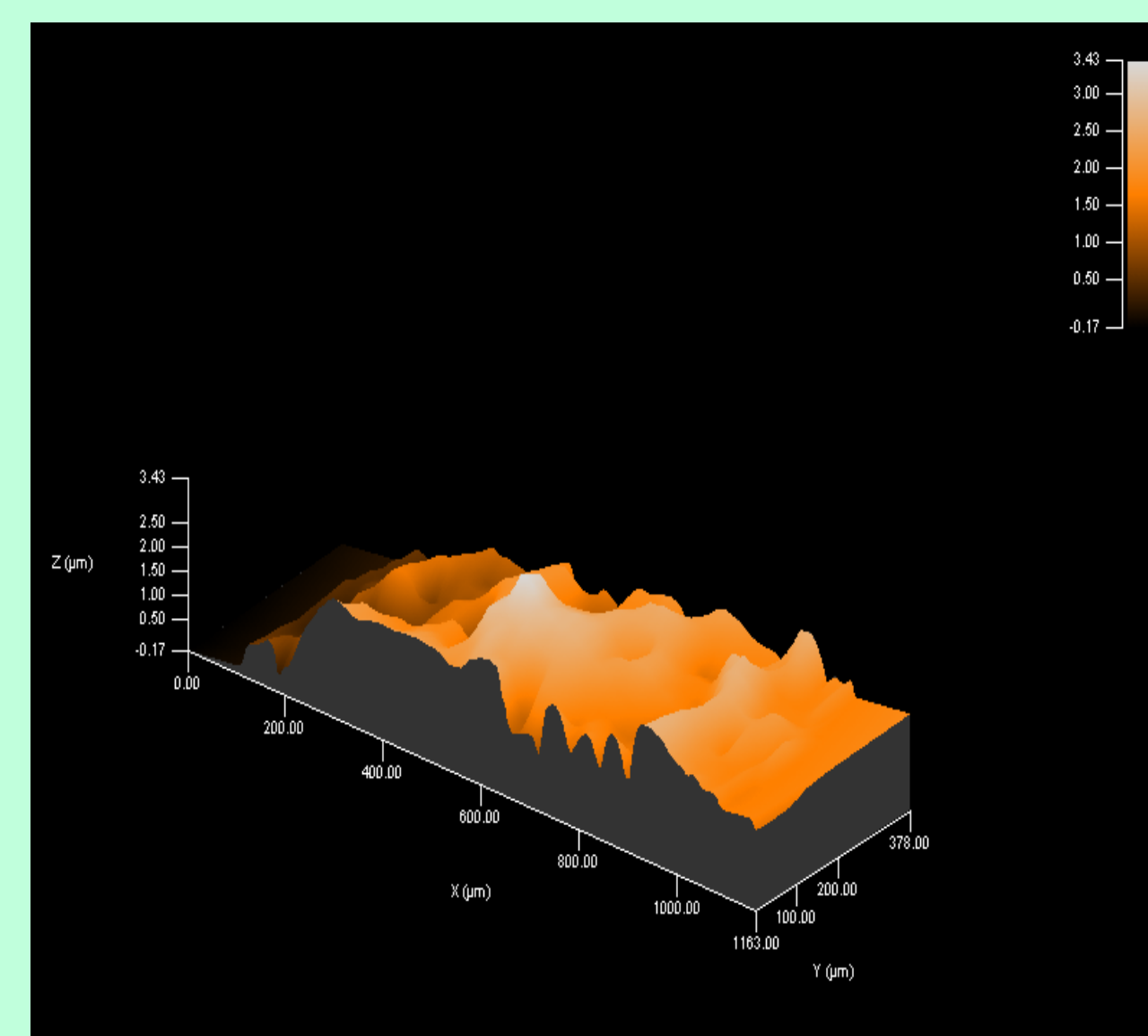- Processing Temperature: 100-400C

Test structure

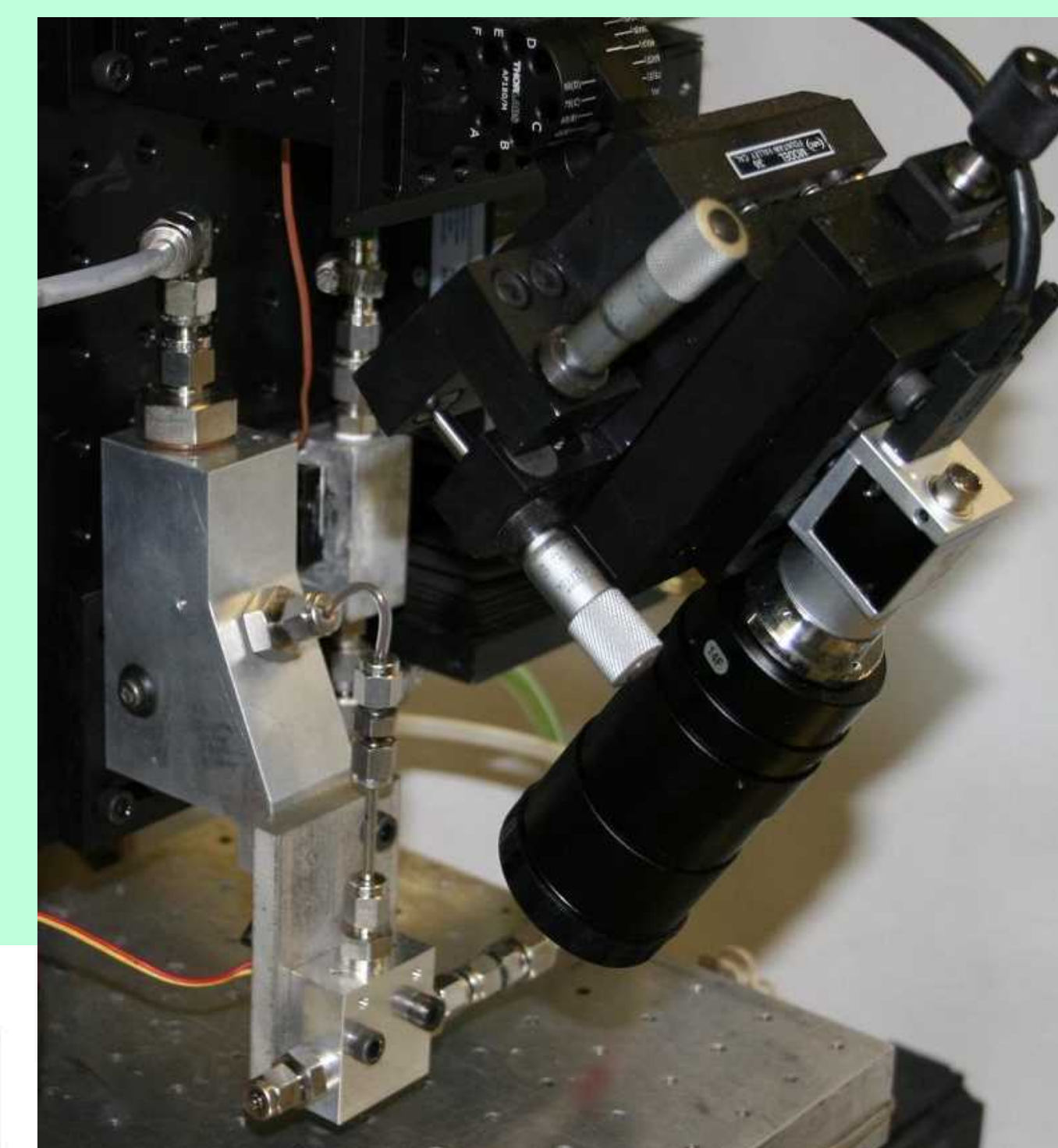- Conductive Ag particles are deposited on Au pads to provide an electrical path between die.

Ag deposition

Bottom die

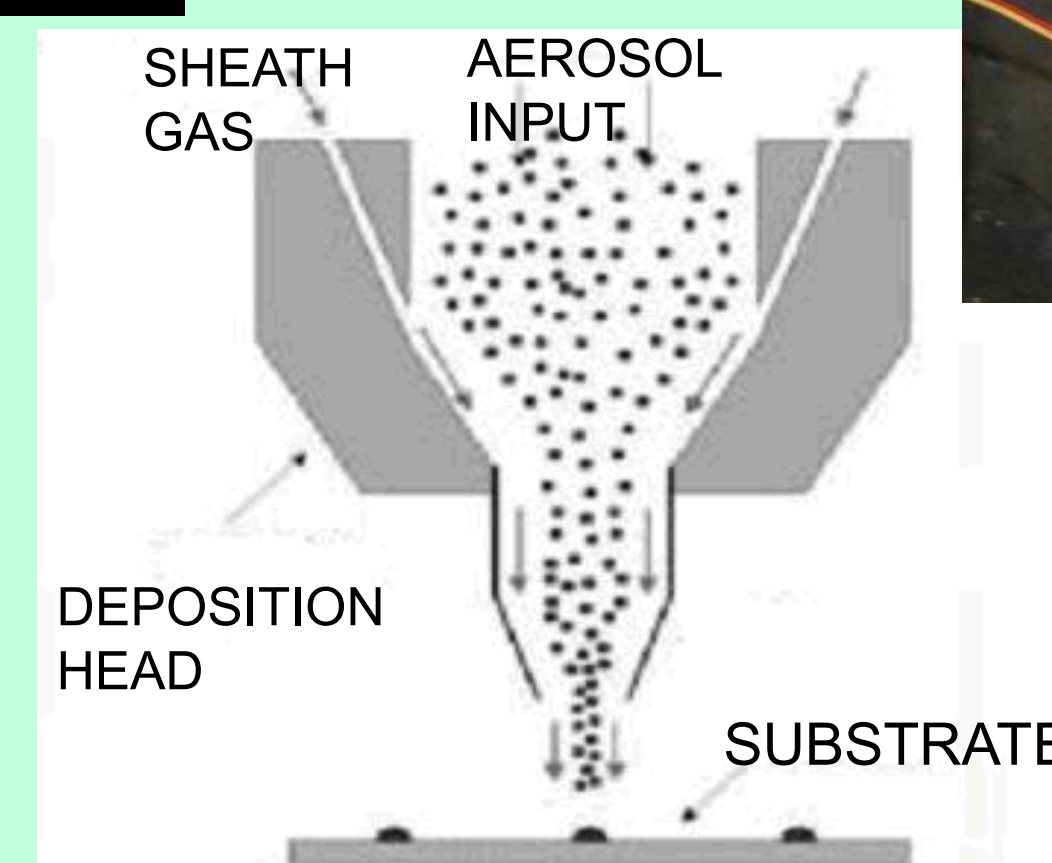Top coupon

Ag line on coupon

Ag bump on open pad
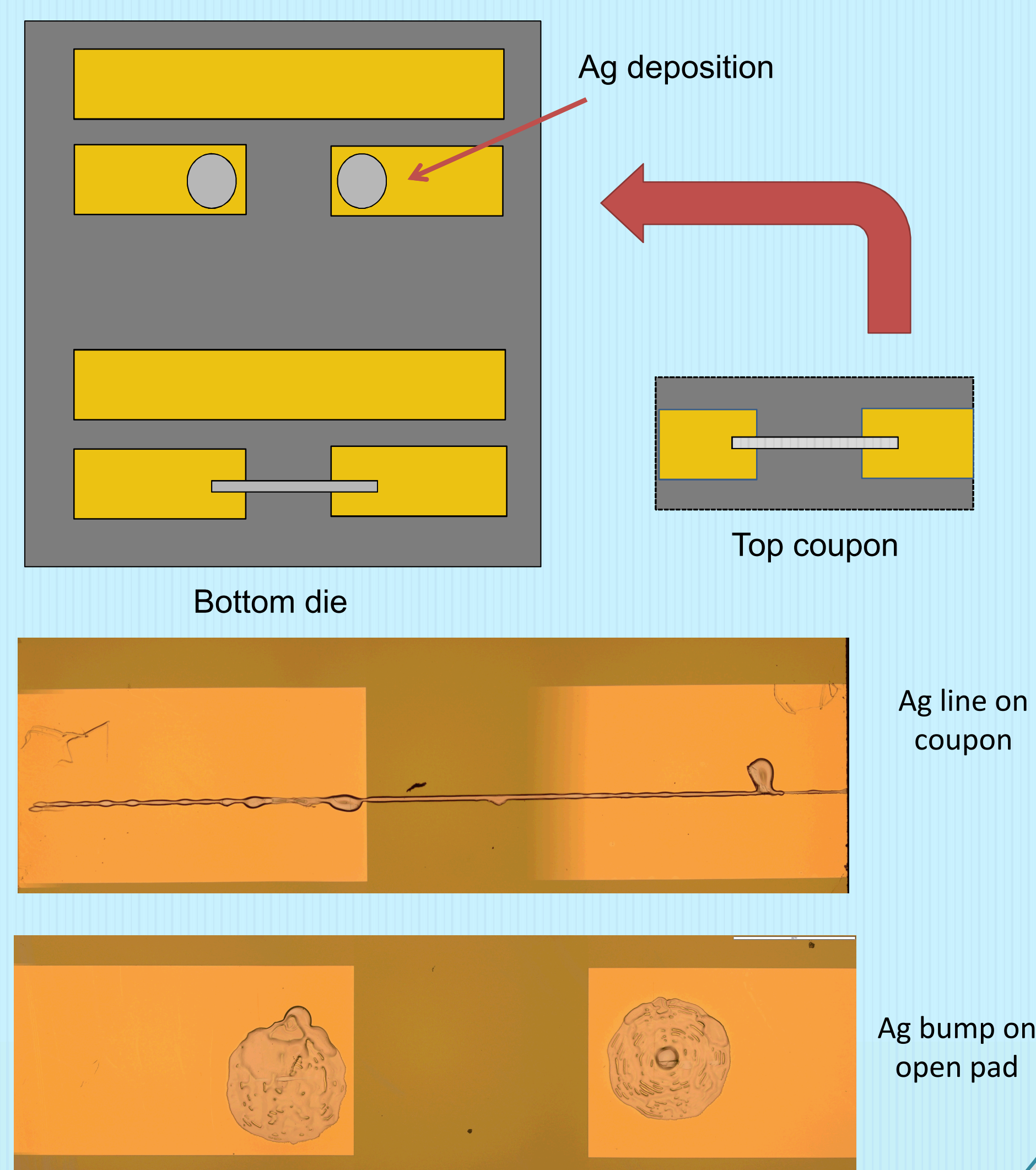
Procedure:

Ag bump/trace deposition

- Programmable fluid dispenser
- Oven cured from 100-400C
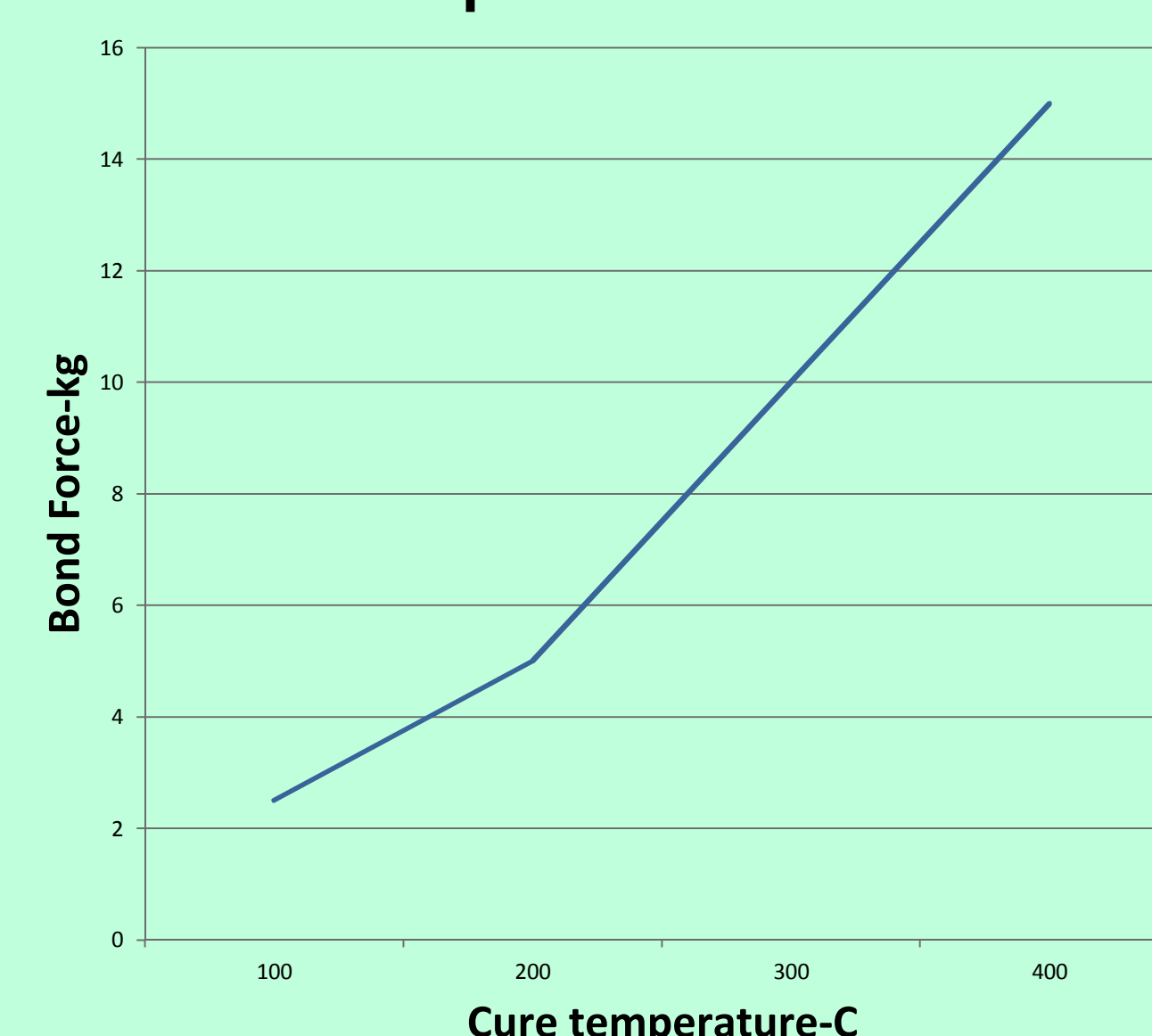
Cross section of bump

SHEATH GAS
AEROSOL INPUT
DEPOSITION HEAD
SUBSTRATE

Microjet printer

Bonding

- Flip chip processing
- Varied amount of applied force
- Requires a mechanical bond to test parts

Bond Force-kg vs Cure temperature-C

This graph shows the pressure needed to bond the Ag epoxy increased as cure temperature increased. Bonded forces used were 2500g, 5kg, 10kg, 12kg and 15kg
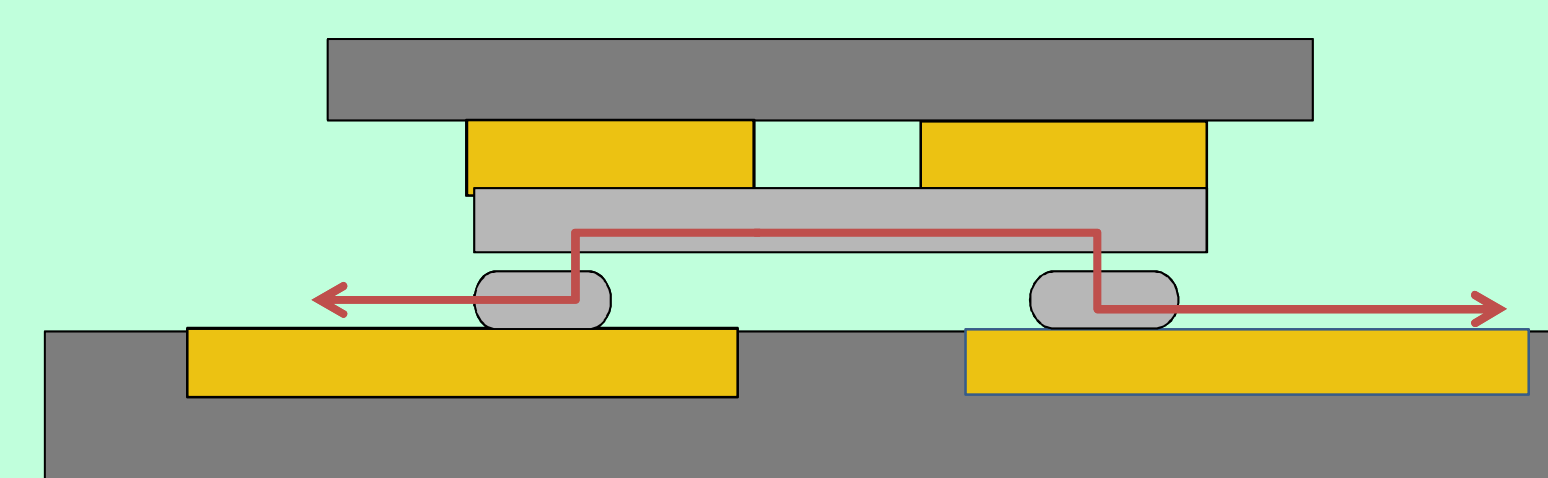
Post Bond (Side View): Shows the 3D electrical path after flip chip bonding

Deposit large scale bumps and lines. Flip and bond small coupon to align Ag line on top of Ag bumps to close the circuit and provide an electrical pathway

Results

- Post bond Ag bump transfer
- Electrical conductivity was shown in the Z direction

After separating the two die post bond, a faint line was visible across the bump indicating a transfer of the Ag ink line that was bonded across the area.
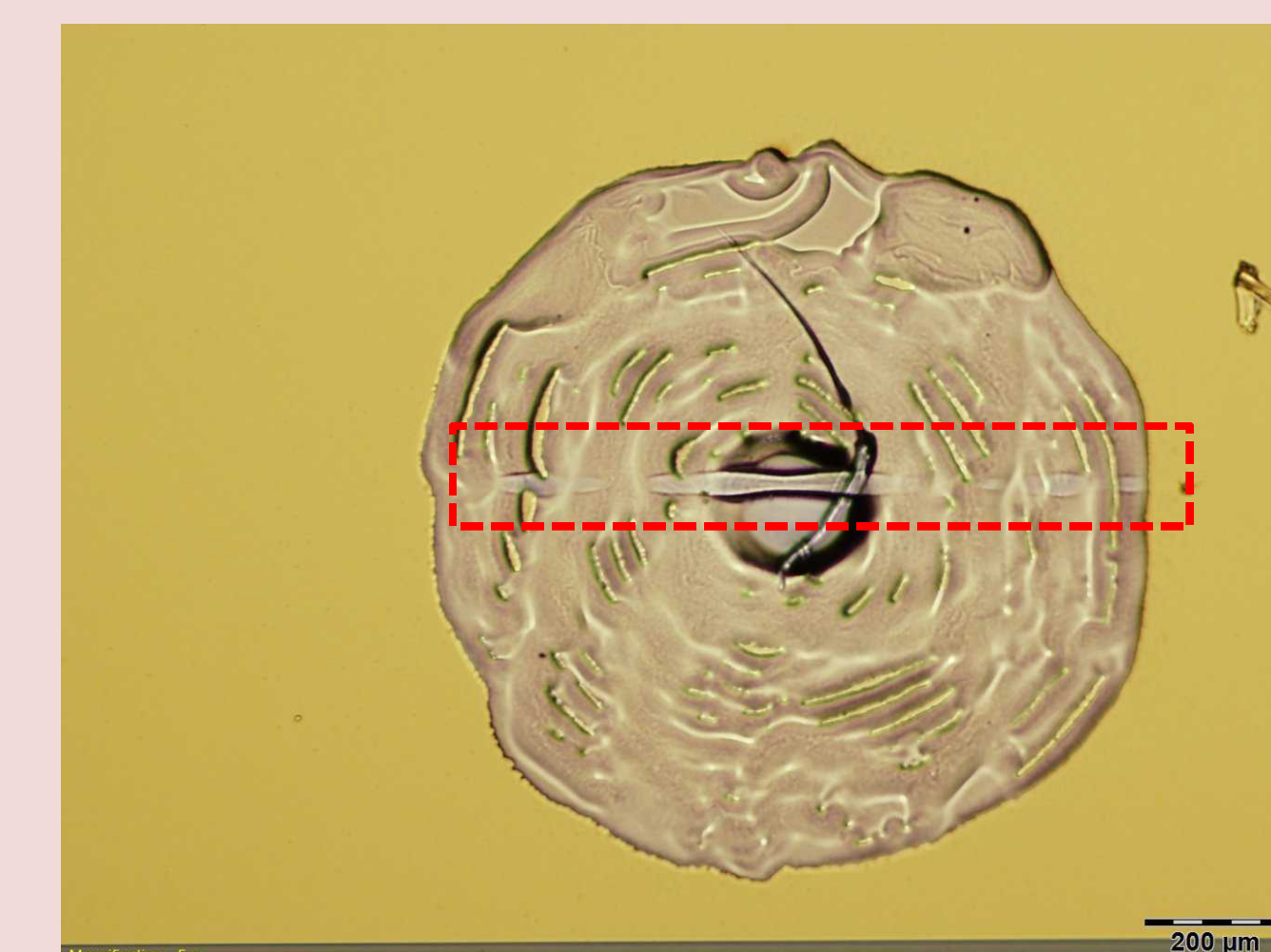
Die	1	2	3	4
Pre-bond electrical measurement (Ω)	2.8	3.7	1.93	3.25
Post-bond electrical measurement (Ω)	4.2	4.0	3.2	5.1
Pre-bond Resistivity (Ω-mm)	$1.12e^{-4}$	$1.35e^{-4}$	$0.8e^{-4}$	$1.97e^{-4}$
Post-bond Resistivity (Ω-mm)	$1.27e^{-4}$	$1.62e^{-4}$	$1.33e^{-4}$	$2.3e^{-4}$

Resistivity is nominalized by the area of the conduction path way using:

$$\text{Resistivity} = \left(\frac{A}{l}\right) * resistance$$

Future Work

- Scale work to relevant applications.
- Continue bonding to increase our data bank

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration