SiLITRONICS

An OSAT Perspective on

Integrated Photonics Assembly Challenges for High Volume

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Outline

- Introduction to the OSAT Model
- Photonics Market and Outlook
- Challenges
- Solutions
- Summary

The OSAT Model

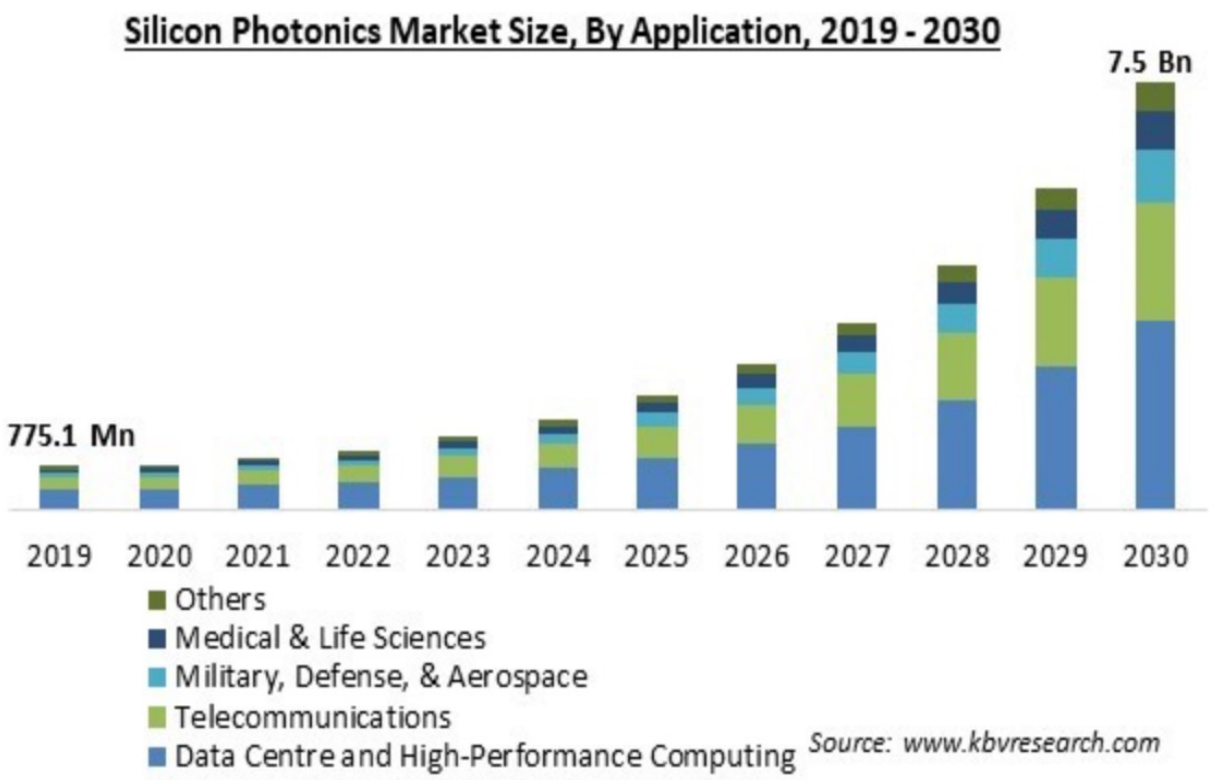
- **Meaning:** Outsourced Semiconductor Assembly and Test (OSAT) are companies that offer 3rd party IC-packaging and test services.

- **Role:** OSATs optimize **costs, yield, and cycle time**. OSATs leverage **economies of scale due to high volume.**

- **OSAT:**
  - Traditional IC Packaging
  - Traditional IC Test
  - High Mag Inspection of IC
  - Optical Package + PIC + Laser + Waveguide
  - Optical Power Test with Pre/Post Alignment
  - Optical Inspection of Side + Cavity + Round

- Now, OSATs need to provide **IC packaging + Optical packaging** with full **Turnkey Services.**

The Silicon Photonic Market



- As market grows, large OSATs are bringing in advanced IC and optical assembly within the same OSAT facility.

- OSATs are helping customers to streamline photonics assembly – as long as **challenges** are addressed before ramp-up.

Challenges for OSAT Model

- Quick-turn support for prototypes (many DOEs)
- NPI requires significant versatility (diff re-config of equipment)
- Fewer industry standards
  - For example: Deciding on a laser source and receiver combination – O, C, or L Band depending on required intensity and polarization
- Photonics Assembly has many variables which pose unique challenges

PIC Photonics Assembly

- Coupler type
- Coupler structure
- Coupler pitch
- Wavelength
- Polarization
- Optical intensity
- Index of refraction
- Fiber type
- Connector type

IC Wire Bond

- Wire Diameter
- Wire material

IC Flip Chip

- Bump size
- Bump type
- Die size/thickness

Engineering Challenges

- Placement - critical axes from 3 ➡ 6 exponentially increases placement difficulty.
- Sub-micron directional and 10 arcsecond rotational tolerances must be met.
- Current automated assembly machines are designed to be custom solutions
    - Reconfigurable platforms tend to be lab-grade which are not suitable for OSAT volume production.
- Process development DOEs cycle time varies from 1 to 20 weeks.
- Optical packaging is highly multi-disciplinary; requiring optics, electronics, materials, and algorithmic engineering knowledge to design a functional alignment and assembly routine.

Material (BOM) Challenges

- Engineering complexity and working within an emerging industry limits OSAT ability to stock standard assembly BOMs.
  - Different foundries and coupler types require different epoxies with different indices of refraction.
  - 2 or more epoxies in and around the optical path to get less than 3db loss.
- Fiber arrays are significantly complex with substantially more variables than other OSAT required materials in standard IC assembly (wire-bond/flip-chip).
  - Fiber pitch, fiber type, # of fibers, polarization direction, fiber thickness, block thickness, polishing angle, connector type, and protrusion.
  - Those requirement limit which fiber arrays can be used; thus, increase cost and cycle time.
- These BOM variations make it more difficult for OSATs to take advantage of Economies of Scale.

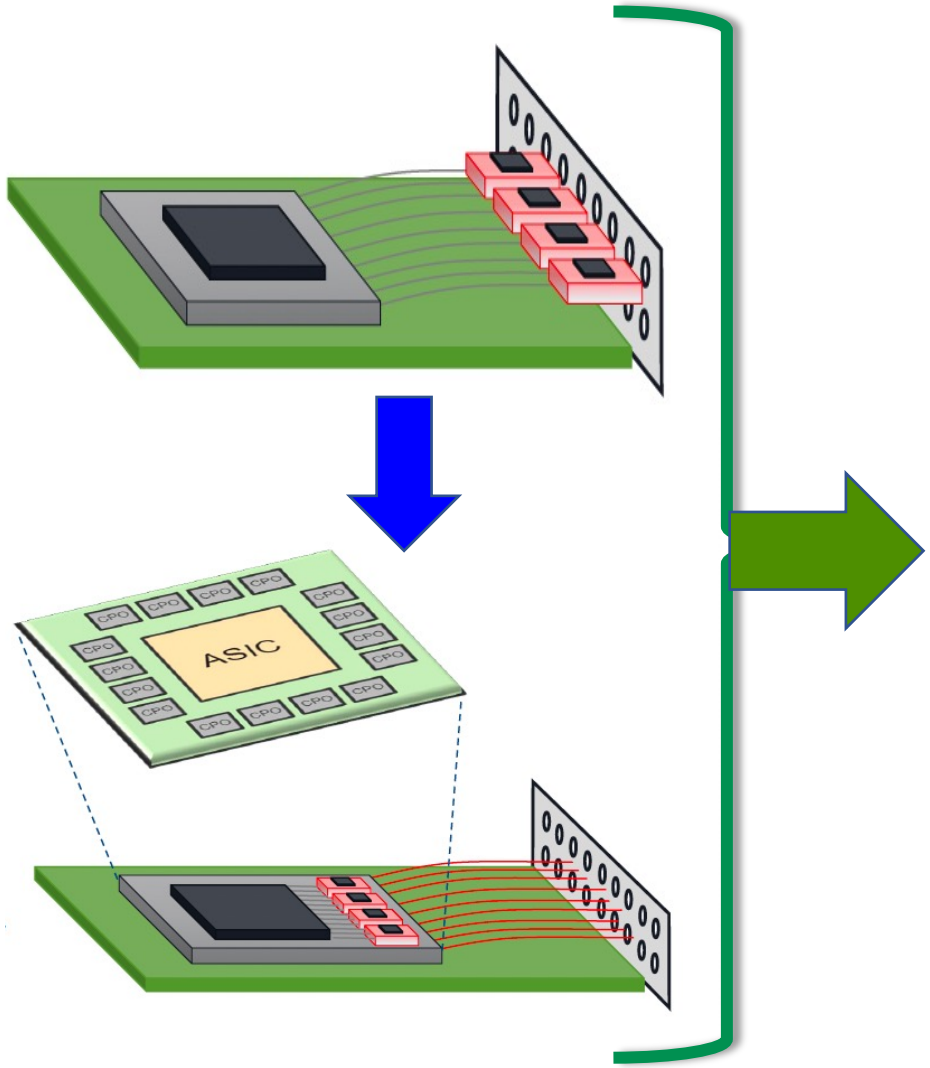
Challenge: NRE Before Photonic Assembly

- **Tooling**: Tooling for active alignment machines includes:
    - FAU pickup tool.
    - PIC holder.
    - Monitor PD prober.

- **Machine Reconfiguration**: Parts of alignment machines are removed, added or moved based on the application.
    - Moving the cameras and UV lamps for better sightlines.
    - Adding or removing a probe or reconfiguring to act as a voltage driver.
    - Installing the laser source and photometer for the desired wavelength.

- **Process Setup and Optimization:** The process must be written and optimized individually for the application.
    - Fiducial alignment.
    - Alignment algorithms, steps, and set limits.
    - UV and heat curing profiles.

Photonics Assembly (PIC+IC+FAU) @ Silitronics



- Substrate 60 x 60 Build Up
- PIC 25mx25mm
- 2 FAU with 1x12 each
- 2 ICs with 20,000 Cu Pillar
- 1 PIC with 15,000 bumps
- 100% NRE @ Silitronics
- Full DOE @ Silitronics
- OSAT Transfer for High Volume

OSAT Facility: Fully Automated for DOE & NPI

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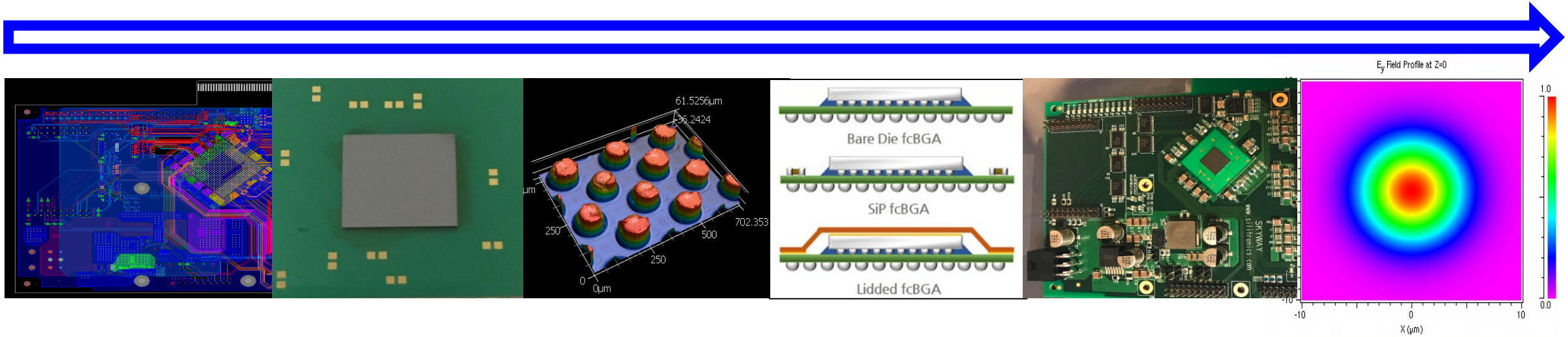
IP Protection: Co-development in-house with customers' engineers

✓ISO 9001:2015

✓ITAR

OSAT: Full Turn-Key Photonics Assembly Services



Design + Substrate Fab + Assembly

Design	SI/PI	Fabrication	Dicing	Flip Chip
4 weeks	2 weeks	10-14 weeks	4 hrs	2 days

Board + PCBA + Auto Active Alignment

Design	Fabrication	PCBA	Alignment
1 week	1 week	1 day	1 to 5 weeks

Summary

OSATs are trying to understand market as Silicon Photonics expands

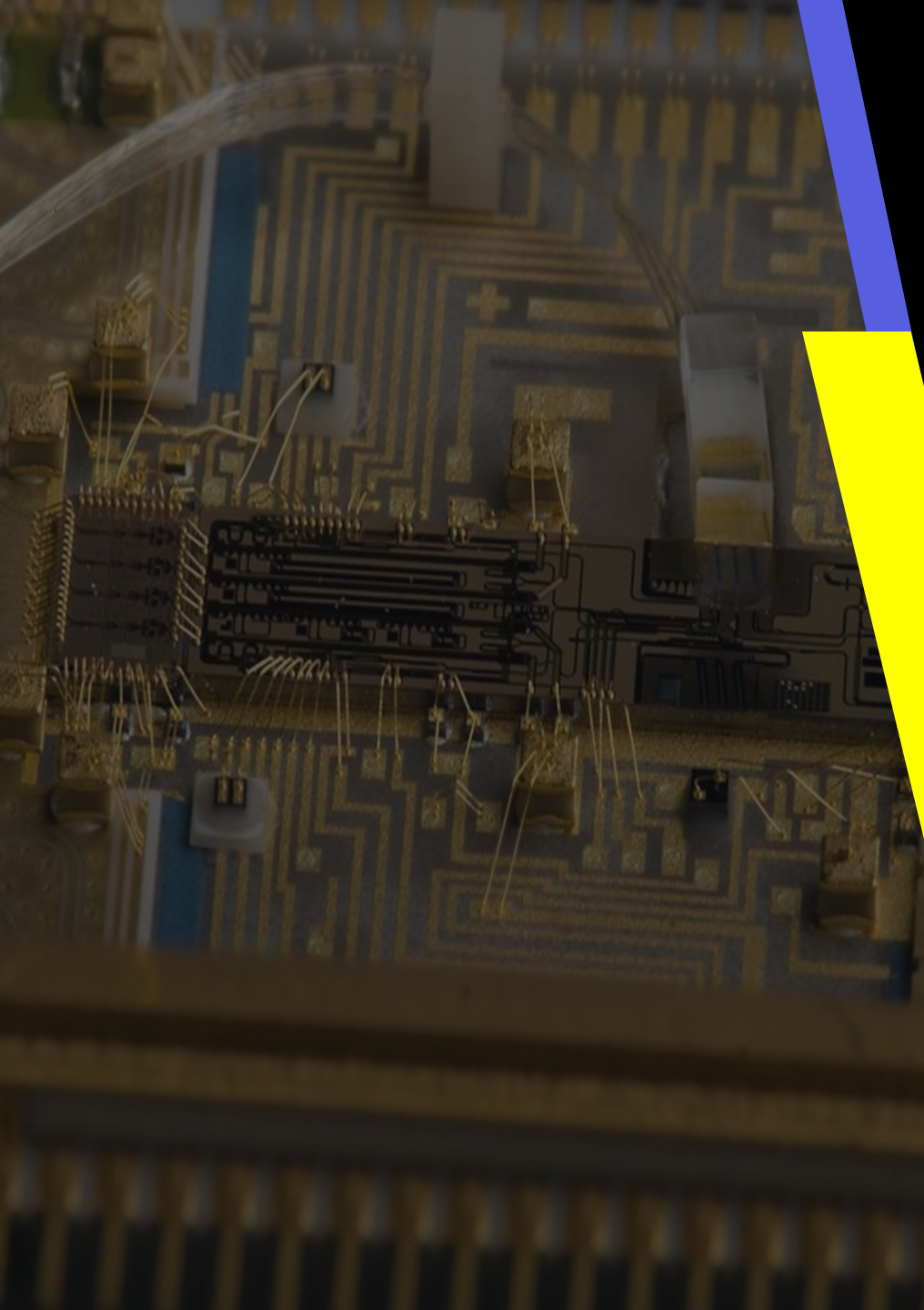
Partner with “Right” OSATs, on day 1, to shorten development time

OSAT needs to invest in engineering technology before volume grows

Advanced equipment for PIC wafer testing, active alignment, and final test

Silitronics made several investments to establish US OSAT leadership

These resulted in wins at Hyperscaler, T1 OEMs, and leading startups in AI/ML/Cloud technologies



Thank you!

Your one-stop OSAT partner for

IC + Photonics Assembly

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