IEEE ELECTRONICS PACKAGING SOCIETY
ECTC
The 2023 IEEE 73rd Electronic Components and Technology Conference

Advanced Packaging Manufacturing in North America: Building the Ecosystem

Tuesday, May 30, 2023, 3:30 p.m. – 5:00 p.m.

Chairs: Nancy Stoffel (GE Research), Jan Vardaman (TechSearch International), and William Chen (ASE)

ECTC 2023 Special Session 4

IEEE ELECTRONICS PACKAGING SOCIETY

ECTC The 2023 IEEE 73rd Electronic Components and Technology Conference

Chair
Nancy Stoffel
GE Research

Chair
William Chen
ASE

Chair
Jan Vardaman
TechSearch International

Panelist
Frank Gayle
NIST

Panelist
Carl McCants
DARPA

Panelist
Joshua Dillon
Marvell Technology Inc.

Panelist
Subramanian Iyer
UCLA

Panelist
Dick Otte
Promex Industrics, Inc.

Panelist
Hem P. Takiar
Micron Technology Inc.

Advanced Packaging Manufacturing in North America: Building the Ecosystem

North America has companies that excel in design for electronics systems, device, and advanced packaging. However less than 2% of the packaging occurs in the US. This session will discuss the ambitious goals being set through the CHIPS ACT to bring Advanced Packaging to North America. We will review the targets and developing plans of the US government, funded through the CHIPS Act. The panelists will overview major initiatives launched in R&D and Manufacturing. We will also discuss the challenges to meeting the goals.

Manufacturing 3-Dimensional Heterogeneously Integrated (3DHI) Microsystems

Dr. Carl McCants, DARPA Special Assistant - ERI

Briefing Prepared for 2023 IEEE Electronic Components and Technology Conference

May 30, 2023

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MTO thrust areas

DISRUPTIVE MICROSYSTEMS

- **SEE** — Gaining an advantage in sensing the physical world
- **TALK** — Securing communications
- **ACT** — Increasing the effectiveness of radiation on target
- **NAVIGATE** — Embedding accurate positioning and timing

EDGE PROCESSING

- **COMPUTE** — Increasing information processing efficiency at the edge
- **DECIDE** — Accelerating innovation in AI hardware

MICROSYSTEMS MANUFACTURE

- **BUILD** — Manufacturing complex 3D microsystems
- **COMPOSE** — Optimizing design and test for complex circuits
- **SECURE** — Overcoming security threats across the entire hardware lifecycle
- **HARDEN** — Developing electronics for extreme environments

3D: Three-dimensional
AI: Artificial Intelligence

https://www.darpa.mil/about-us/offices/mto

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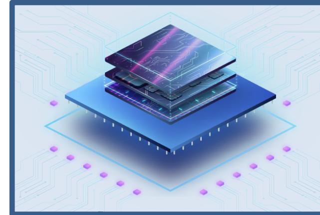
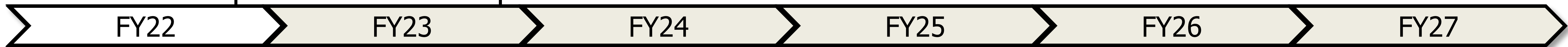
Electronics Resurgence Initiative (ERI) 2.0 timeline

NGMM Phase 0 BAA
August 2022

ERI Summit 2023
August 22-24 / Seattle, WA





Original ERI | **ERI 2.0: Reinventing microsystems manufacturing for a new age**

TALK

Securing communications

COMPUTE

Increasing information processing efficiency at the edge

DECIDE

Accelerating innovation in AI hardware

BUILD

Manufacturing complex 3D microsystems

COMPOSE

Optimizing design and test for complex circuits

SECURE

Overcoming security threats across the entire hardware lifecycle

HARDEN

Developing electronics for extreme environments

NGMM: Next-Generation Microelectronics Manufacturing program

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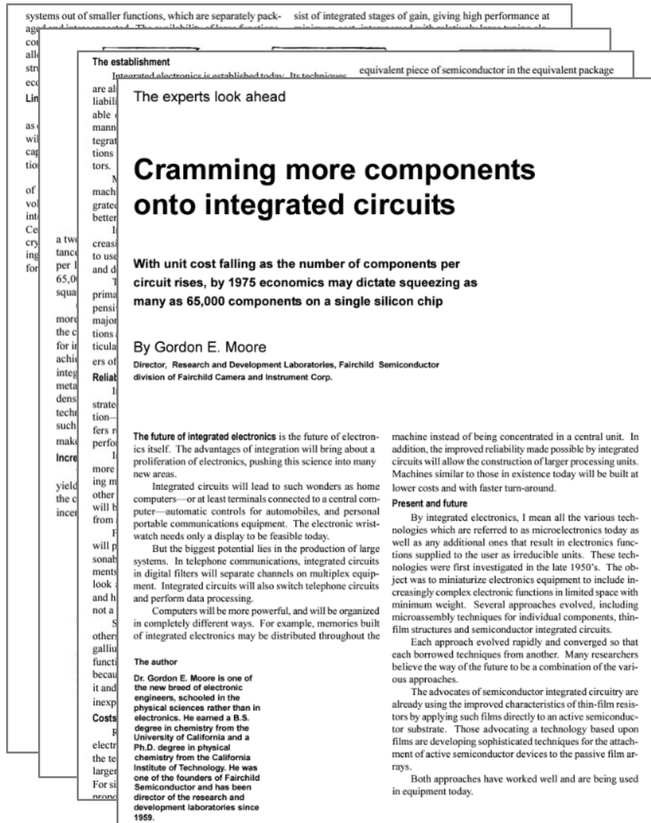
Disaggregation*



The experts look ahead

Cramming more components onto integrated circuits

With unit cost falling as the number of components per circuit rises, by 1975 economics may dictate squeezing as many as 65,000 components on a single silicon chip

By Gordon E. Moore

Director, Research and Development Laboratories, Fairchild Semiconductor division of Fairchild Camera and Instrument Corp.

The future of integrated electronics is the future of electronics itself. The advantages of integration will bring about a proliferation of electronics, pushing this science into many new areas.

Integrated circuits will lead to such wonders as home computers—or at least terminals connected to a central computer—automatic controls for automobiles, and personal portable communications equipment. The electronic wristwatch needs only a display to be feasible today.

But the biggest potential lies in the production of large systems. In telephone communications, integrated circuits in digital filters will separate channels on multiplex equipment. Integrated circuits will also switch telephone circuits and perform data processing.

Computers will be more powerful, and will be organized in completely different ways. For example, memories built of integrated electronics may be distributed throughout the machine instead of being concentrated in a central unit. In addition, the improved reliability made possible by integrated circuits will allow the construction of larger processing units. Machines similar to those in existence today will be built at lower costs and with faster turn-around.

The author

Dr. Gordon E. Moore is one of the new breed of electronic engineers, schooled in the physical sciences rather than in electronics. He earned a B.S. degree in chemistry from the University of California and a Ph.D. degree in physical chemistry from the California Institute of Technology. He was one of the founders of Fairchild Semiconductor and has been director of the research and development laboratories since 1959.

Present and future

By integrated electronics, I mean all the various technologies which are referred to as microelectronics today as well as any additional ones that result in electronics functions supplied to the user as irreducible units. These technologies were first investigated in the late 1950's. The object was to miniaturize electronics equipment to include increasingly complex electronic functions in limited space with minimum weight. Several approaches evolved, including microassembly techniques for individual components, thin-film structures and semiconductor integrated circuits.

Each approach evolved rapidly and converged so that each borrowed techniques from another. Many researchers believe the way of the future to be a combination of the various approaches.

The advocates of semiconductor integrated circuitry are already using the improved characteristics of thin-film resistors by applying such films directly to an active semiconductor substrate. Those advocating a technology based upon films are developing sophisticated techniques for the attachment of active semiconductor devices to the passive film arrays.

Both approaches have worked well and are being used in equipment today.

Source: Electronics, Volume 38, Number 8, April 19, 1965

"It may prove more economical to **build large systems out of smaller functions, which are separately packaged and interconnected**. The availability of large functions, combined with functional design and construction, should allow the manufacturer of large systems to design and construct a considerable variety of equipment both rapidly and economically."

– Gordon Moore

*a.k.a.

- *Polylithic*
- *Pseudo-lithic*
- *Chiplet-based*
- *3DHI*

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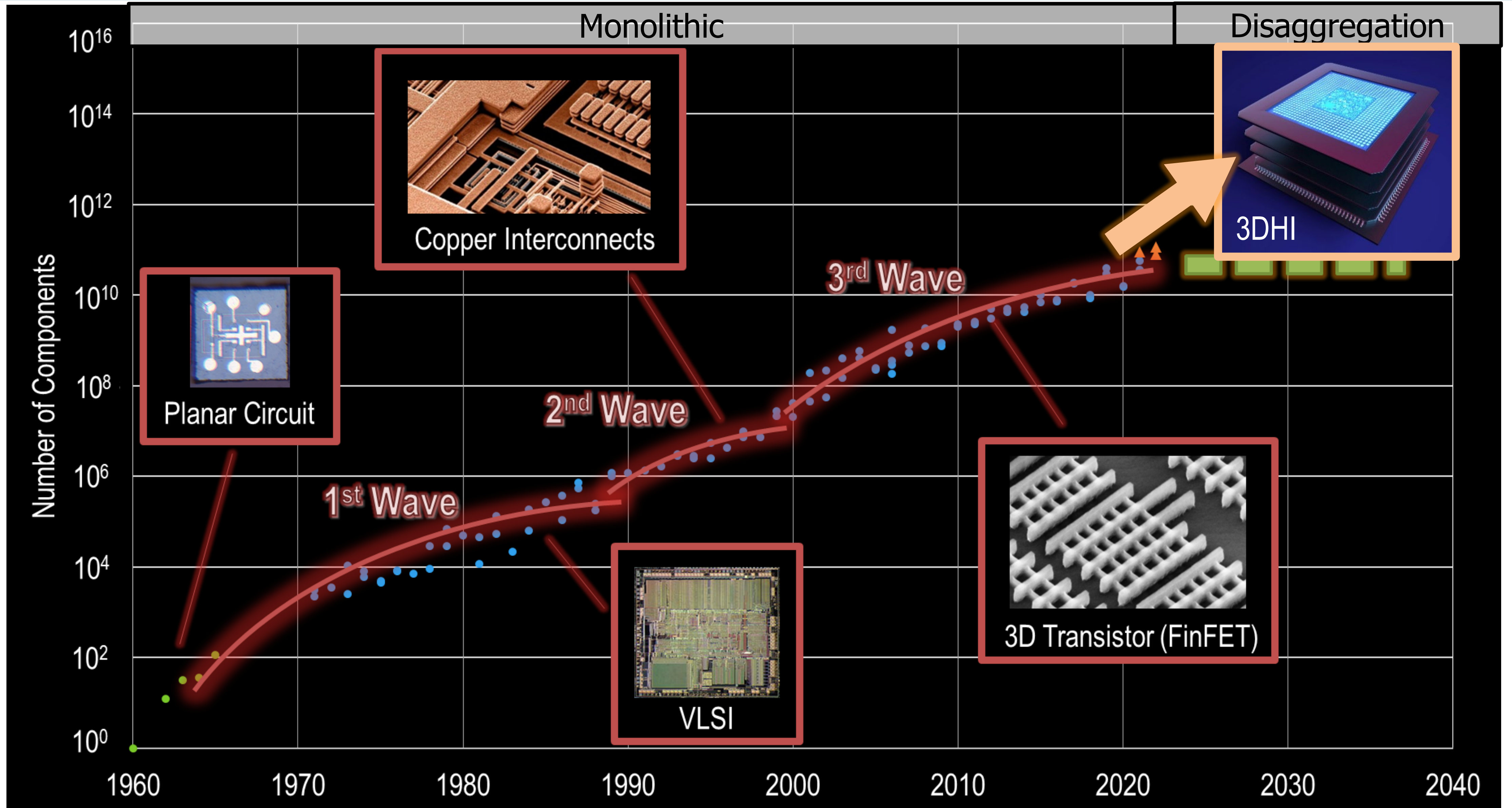
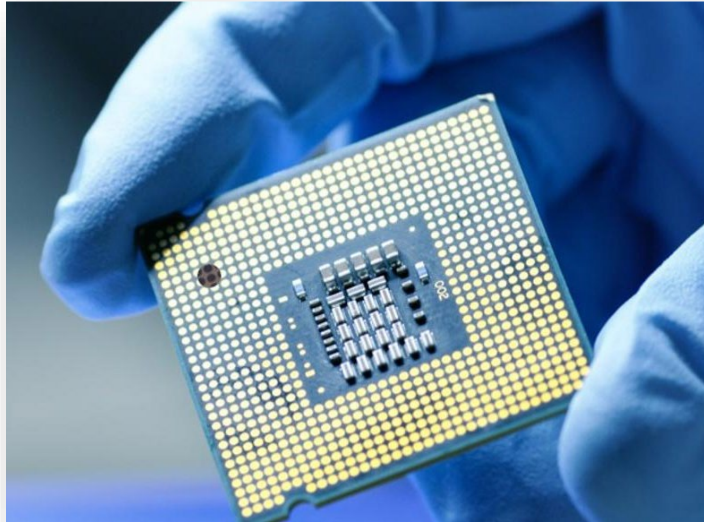
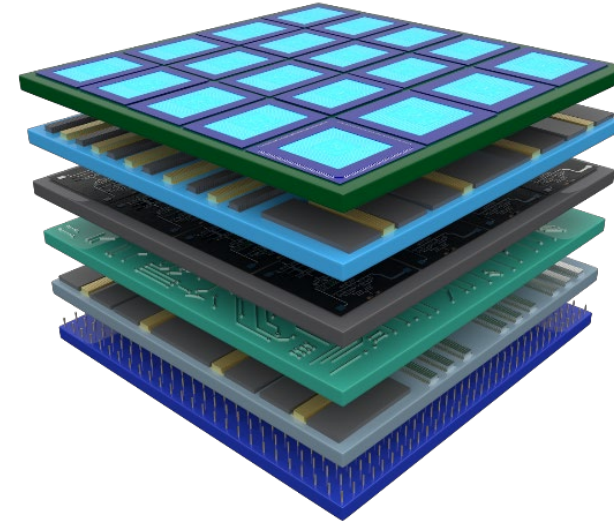
Progress in microelectronics



Microsystems





Today	Future
2D	3D with dense interconnects
Monolithic integration	Disaggregation
Silicon	Multi-process / multi-material
Packaged after fabrication	Packaging no longer distinct

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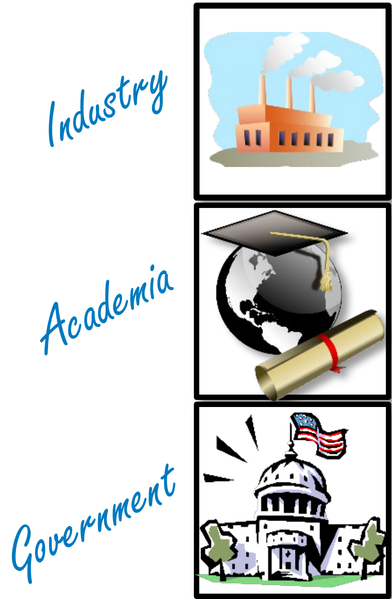
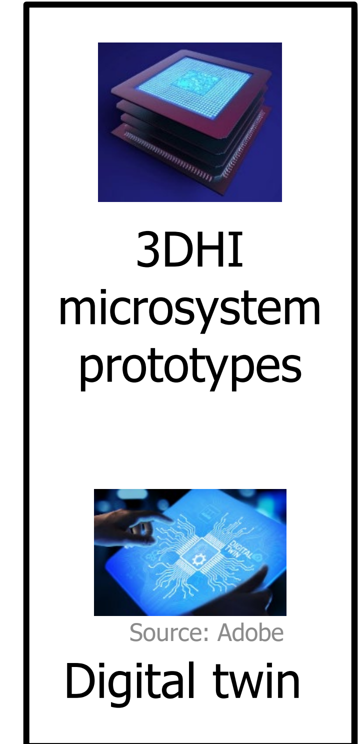
NGMM: national capability for 3DHI R&D and low-volume manufacturing

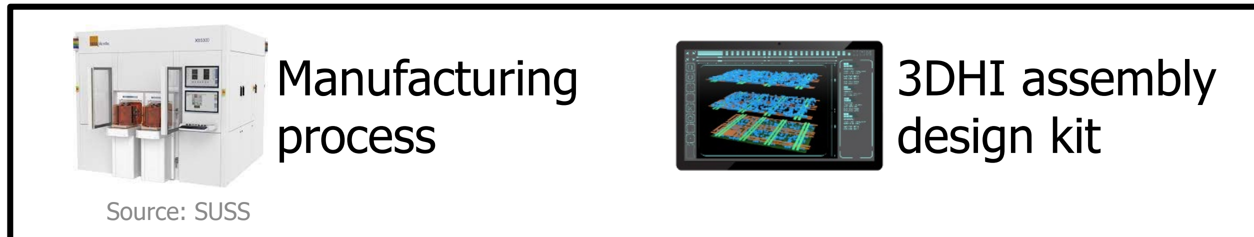
Users | **National capability** | **Output**



Source: Creative Commons

Source: Adobe Stock





3DHI: Three-dimensional heterogeneous integration

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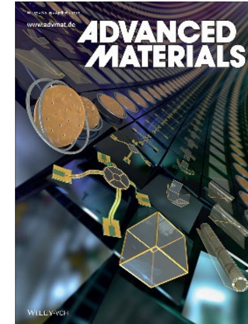
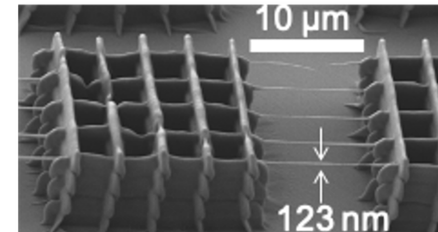
Making 3DHI real – R&D focus areas

Necessary 3DHI focus areas

- **Multi-chip, multi-technology assembly / packaging**
  - Compatible die-to-die, wafer-to-wafer, die-to-wafer, and wafer-to-board processes
  - Desktop assembly
- **3DHI interconnects**
  - Precisely aligned lateral interconnects through fine-scale printing and additive manufacture
  - Post-commercial-3DHI TSVs (through-substrate-via)
- **Thermal and power**
  - Embedded thermal management within assembly and package
  - Materials to extend temperature operation range
  - Low-loss passives for power distribution
  - Efficient power conversion in assembly / package
- **Tools for design, simulation, and test**
  - 3DHI metrology
  - Multi-domain, integrated EDA tools for 3DHI
  - Validation of complete digital models
- **"MOSIS-like" 3DHI prototyping services**
  - Baseline 3DHI fabrication processes
  - 3DHI multi-project and taxi run demos with 3D-ADK (3D Assembly Design Kit)



3D Microelectronics: 3D Self-Assembled Microelectronic Devices: Concepts, Materials, Applications (Adv. Mater. 15/2020)



Saha et al., Science, Vol. 366, Issue 6461, pp. 105-109, 2019

Source: Gorodenkoff

Making 3DHI electronics a reality requires focused R&D and pilot-line manufacturing capability

3DHI: Three-dimensional heterogeneous integration

www.darpa.mil

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ECTC Panel
“CHIPS ACT Implications”

Richard F. Otte
Promex Industries Inc.
May 30, 2023

Promex

Microelectronics Assembly Technologies

Where do firms, like us, find the other 2/3 of the $?

Promex
Microelectronics Assembly Technologies

“Other” Funding Sources

- Operating Funds
- Loans against Company Assets
- Industrial Partners
- Local Government. Especially States
- Professional Investors
  - Family Offices
  - Some Private Equity

Who will the customers be for US based Packaging services ?

Two Separate Needs

Promex
Microelectronics Assembly Technologies

- More Than Moore Concept
  - Smaller nodes
  - Added functionality
- Smaller Nodes Need Advanced Packaging
  - Highest density devices to maximize performance
    - Chiplets
    - Silicon Interposers 2 micron lines & spaces
- Added Functionality Needs mostly Mainstream Packaging
  - Heterogeneous Integration
    - More than Silicon on wafer
    - Unique, non-electronic parts
  - Standard Packages
    - BGA, QFN, etc

What Can be Done to Bring Packaging On-Shore ?

Promex
Microelectronics Assembly Technologies

- The Barriers:
  - Limited on-shore capability
  - Higher on-shore **volume** Costs
- The Benefits:
  - Turn time
  - Able to Visit, Communication, learn
  - Alternate Source
  - Confidentiality
- Consider On-Shore Carefully

Overcoming On-shore Assembly Barriers

Promex
Microelectronics Assembly Technologies

- Focus Investment on the Emerging and Next Generations of Packaging
- Establish and Demonstrate on shore capability
  - Develop Better Technologies
  - Build Pilot Lines
  - Demonstrate Capability & Performance
  - Then Establish Relationships and then Price
- Where is the need & demand ?
  - Heterogeneous Integration
  - Advanced Packages
  - Chiplet Package Assembly