



NextFlex: Flexible Hybrid Electronics

Supporting The DOD Mission

Eric Forsythe, PhD

CCDEVCOM – Army Research Laboratory

Unclassified



FLEXIBLE HYBRID ELECTRONICS: ACHIEVING THE VISION THROUGH PUBLIC PRIVATE PARTNERSHIPS



Public-private partnerships: Enabling FHE Digital Additive US Manufacturing

1. DOD Programs: *DOD Prototyping and Demonstration Devices*
2. Enabling: *Low-cost low-volume manufacturing (Project call investments)*
3. Developing: *US Scale Manufacturing Supply Chain supported by commercial products*
4. Execution: *Flexible Cooperative Agreements and Membership Structures*



-  OSD Funded \$75M+\$96M cost share Core Man'f investments/membership
- FHE pilot line: integrating core man'f investments
- Education Workforce programs



- Supporting Projects: Army Sensor Applications
- Supporting Projects: AF Airmen monitoring
- Advocacy: Sponsor conferences, standards, workshops, Auto-industry and MEMS Group



- Army public-private partnership: contributed to the commercialization of flexible displays
- Army, OSD Mantech, DTRA: commercialization of flexible digital x-ray detector arrays
2004-12 displays 2011-present flexible x-ray



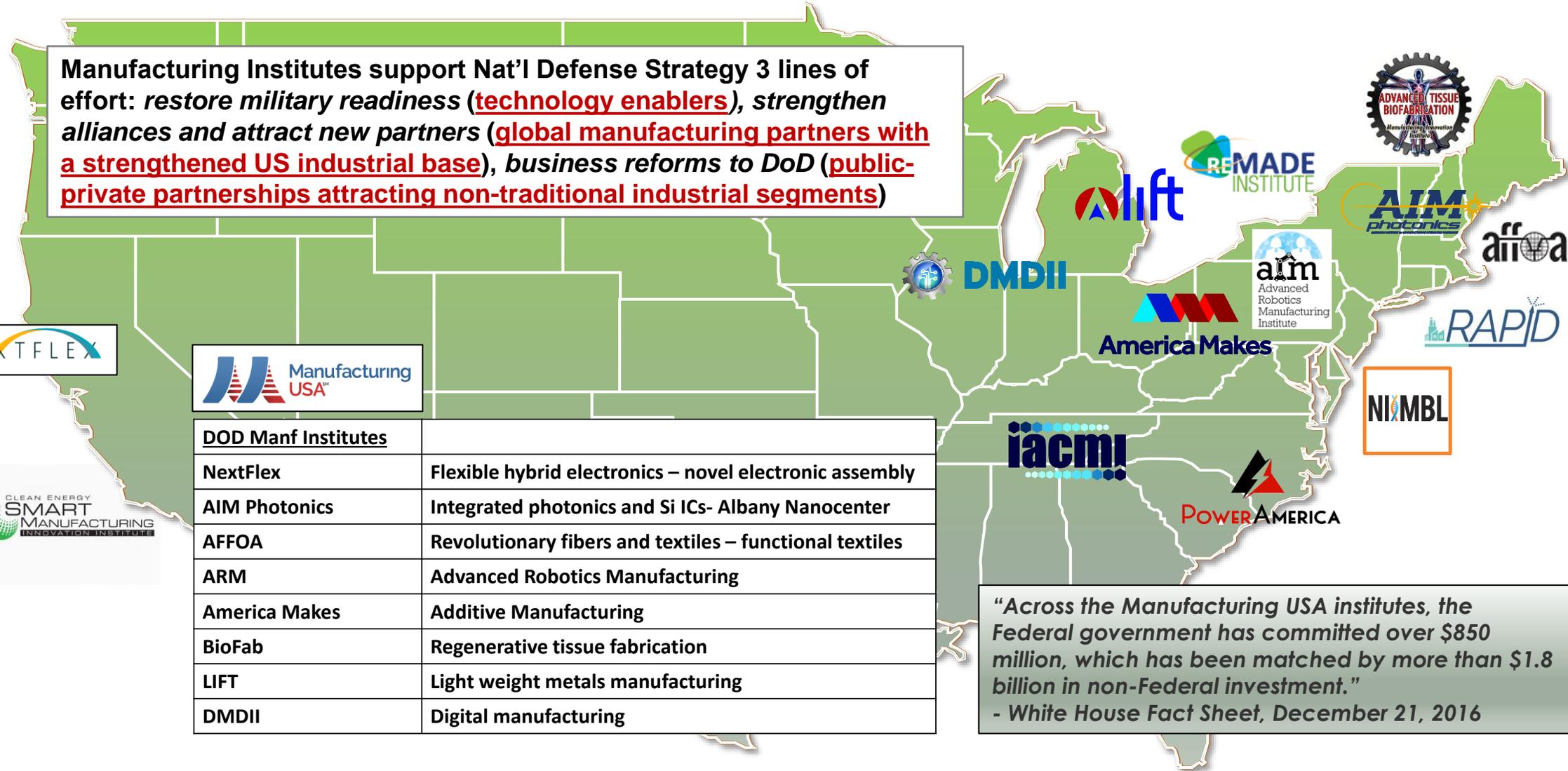
NETWORK OF MANUFACTURING INSTITUTES



Manufacturing Institutes support Nat'l Defense Strategy 3 lines of effort: *restore military readiness (technology enablers), strengthen alliances and attract new partners (global manufacturing partners with a strengthened US industrial base), business reforms to DoD (public-private partnerships attracting non-traditional industrial segments)*



DOD Manf Institutes	
NextFlex	Flexible hybrid electronics – novel electronic assembly
AIM Photonics	Integrated photonics and Si ICs- Albany Nanocenter
AFFOA	Revolutionary fibers and textiles – functional textiles
ARM	Advanced Robotics Manufacturing
America Makes	Additive Manufacturing
BioFab	Regenerative tissue fabrication
LIFT	Light weight metals manufacturing
DMDII	Digital manufacturing



“Across the Manufacturing USA institutes, the Federal government has committed over \$850 million, which has been matched by more than \$1.8 billion in non-Federal investment.”
 - White House Fact Sheet, December 21, 2016



NEXTFLEX: BUILDING THE FLEXIBLE HYBRID ELECTRONICS ECOSYSTEM (5) PROGRAM THRUST AREAS ADVANCING ELECTRONIC ASSEMBLY



1. Industry-Led Man'f Investment:

Shared Risk Reduction

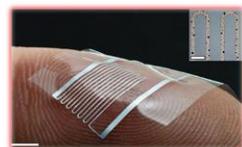


Projects in FHE Electronic assembly



Projects in FHE Tools and materials

Electronic printing



Projects on FHE technology Demos

3. Creative Education-Workforce Development Programs



SOCOM-problems Investment. Training DOD workforce

Background (5) Program Thrusts

Catalyzing a robust and innovative manufacturing ecosystem at the intersection of the electronics and high performance printing industries.

- Funded with \$75M from Department of Defense
- \$96M in committed Cost share
- Non-Profit: FlexTech Alliance, Inc (San Jose CA)
- Flexible Cooperative Agreement

Program Deliverable: SUSTIANABLE FHE ECO-SYSTEM

4. Collaboration: Nationwide Member Network

94 members, 22 Govt Agencies, (200+ SMEs)



2. Integrated Knowledge Capture Pilot Line and materials databas

Silicon Valley Headquarters
Silicon Valley Entrepreneur Staff

FHE electronic assembly pilotline



PKD and Materials databa

5. DOD Transition through Agency

Technology Transition

Knowledge Transition

DOD Business Acumen

Equipment Capability transition

DOD Relevant Manufacturing

\$31.5M additional fundi Leveraging CA

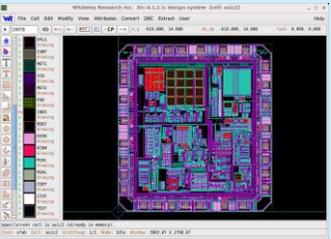


ELECTRONIC ASSEMBLY ECOSYSTEM AND FHE MANUFACTURING



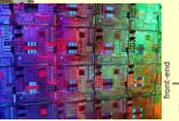
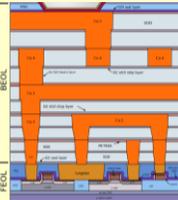
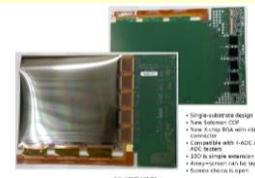
Software Design Tools

Electronic Design Automation EDA (Process Design Kit)



Wafer Fab (Device foundries)

FEOL (front-end-of-line)
BEOL (back-end-of-line)

“Traditional Fabs”:
Silicon ICs, GaAs, GaN, SiC etc

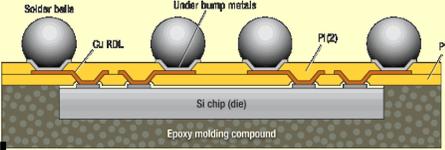
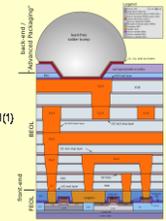
“Non-Traditional Fabs”:
Digital x-ray imaging array fab facilities

- Single-substrate design
- Low substrate cost
- Low 8-chip area with silicon
- Low cost
- Compatible with 1.45C and 1.45C process
- 2D to 3D image extraction of IC
- Image processing can be used
- Better choice for open

Outsource Assembly and Test (OSAT): Middle-end-of-line (Packaging)

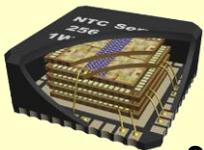
Wafer Level Packaging

Wafer Level Fan-out

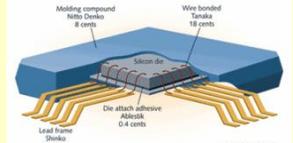
Packaging

System in Package (SiP)
System on Chip



3D Die stacking
Component/Device

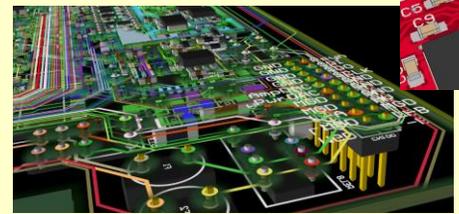
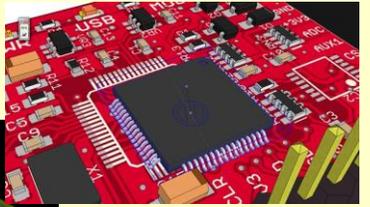
Mold-packaging (lead-frame wire-bonding)



Electronic Manf Services: (Backend Assembly)

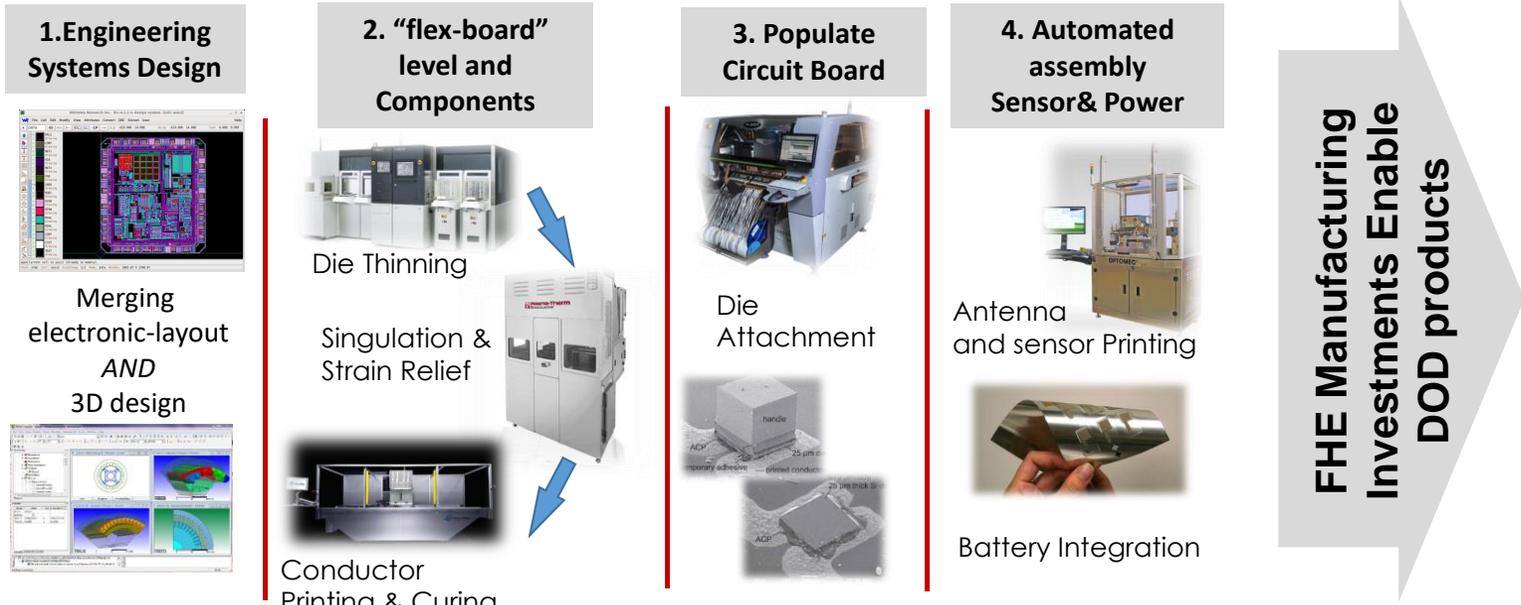
NEXTFLEX Flexible Hybrid Electronics

Additive –digital Manufacturing
Cost per unit independent of volume



DOD RELEVANT PROTOTYPE FACILITY INTEGRATING \$70M OF OUSD(RE) INVESTMENT



KEY Nextflex Pilotline: FLEXIBLE AR...

(www.af.mil/news)
(electronics360.globalspec.com/article...)



AFRL
NextFlex Agency funded Project

TRANSITIONING:

- AFRL for Airmen wearable sensor development (funded)
- Commercial / education opportunities
- AFRL RRTO Proposed program for confined space monitoring

KEY Nextflex Project Success

PARC UCSD: PC 1.0: Technology Demonstrator

"The electrochemical sensor system is fabricated on a small, flexible plastic foil that is mounted on a mouthguard"



47 PR "hits" to date

DOD and Member driven technical roadmaps, man'f gaps, project topics and risk-reduction public-private \$70M Core-OSD + co-investments industry-led		
<ul style="list-style-type: none"> • Open source PDK commercial EDA tools • Link to Mat'l database 	<ul style="list-style-type: none"> • Thin die projects • Printed Interconnects • Adhesive attach 	<ul style="list-style-type: none"> • Printing Circuit layout • Thru-hole via • Die pick-&-place • Printing Passive
<ul style="list-style-type: none"> • System integration • 3D antennas • Power • Encapsulation 		

Project Topics and Pilotline activities



USD(R&E) Dr Griffin's Top 10 Technology Focus Areas

Examples of Opportunity Nextflex FHE Manufacturing Capabilities and Prototypes

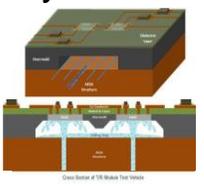


1. **Hypersonics**
2. Directed Energy
3. **Command, Control & Comms**
4. **Space Offense and Defense**
5. Cybersecurity
6. **Artificial Intel/Machine Learning**
7. **Missile Defense**
8. Quantum Science and Computing
9. **Microelectronics**
10. Nuclear Modernization

Integrated Array Antenna Systems

Navy CRANE- MINSEC investments

- High power EW systems



NEXTFLEX Core Investments

- Electronics antennas

Integrated Array Antenna Systems, Device Integration

CERDEC TIDAM soldier authentication

NEXTFLEX Core Investments

- rf-device FHE manufacturing
- Antennas

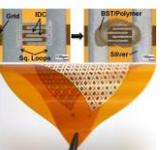
Device Integration & Packaging

AMRDEC – PEO Missiles and Space 3D Optical Sensor for seekers

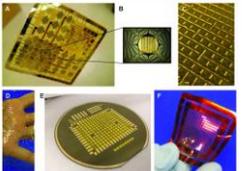
NEXTFLEX Core Investments

Lockheed, Boeing:
Printed Antennas & Integrated Electronics

Raytheon, UM Lowell
rf substrates



Asset Monitoring & Integrated Array Antennas



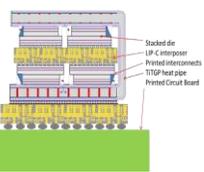
NEXTFLEX Core Investments

NASA partnership

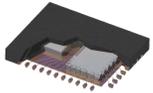
- UTRC Asset Monitoring
- Reduced Weight

NextFlex Core Investment

Navy CRANE- MINSEC Investments



Stacked die
RF components
Printed interconnects
TIDP heat pipe
Printed Circuit Board



A.I. Electronics at Tactical Edge Advance Packaging

NextFlex Core Investment



NEXTFLEX Core Investments
Agency Investments

- Electronic Assembly
- Electronic Packaging
- Non-traditional Foundry (TFT arrays)

