Approved for Distribution

MICRO 3D SYSTEMS™

Advanced Electronic Packaging of Multi Chip Microsystems Enabled by 3D Interconnections

DUJUD

3D PRINTING MICRODEVICES

Company Name: DUJUD
Submission Date: 08/13/2024
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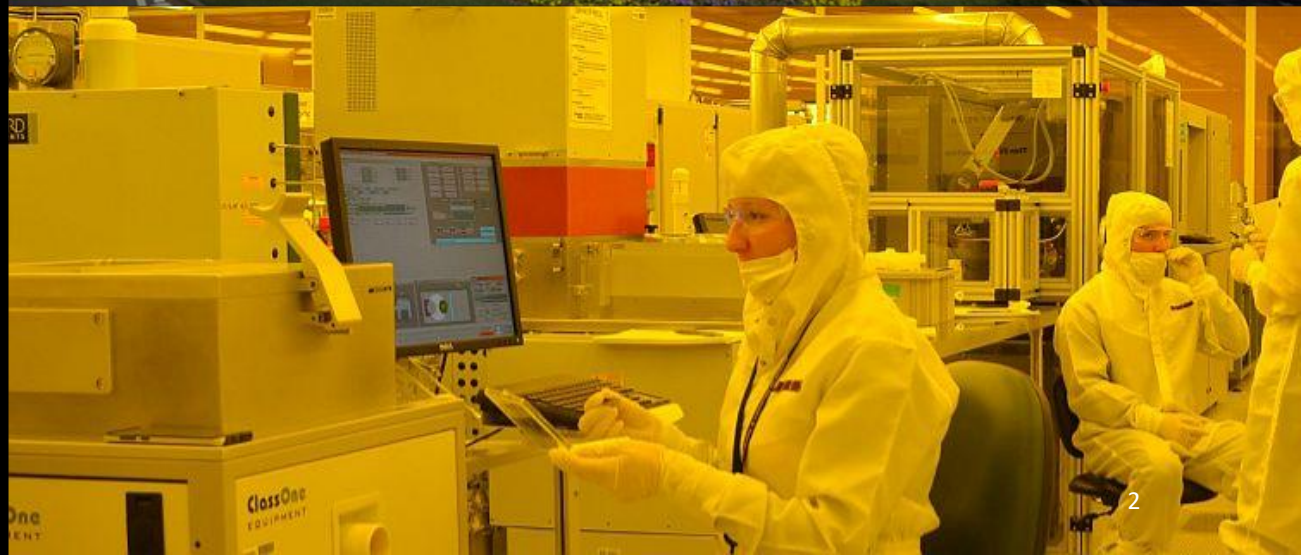
Document version: 2.0

WHO WE ARE

- Founded in 2019
- Headquartered in Atlanta
- Microelectronics Technology Developer
- 12,000 sqft in-house R&D Facility

Ranked #1 in the Inc. 5000 List as the fastest growing company in Computer Hardware Category (based on revenue)

We successfully commercialized 3D printed microdevices



WHO WE ARE

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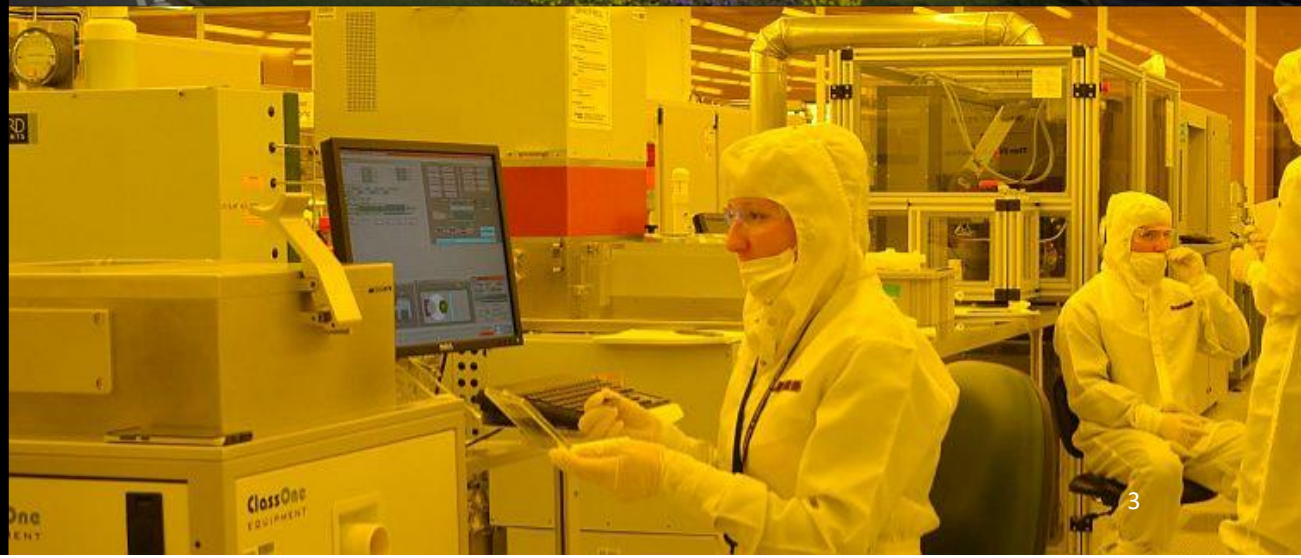
Forbes | NEXT 1000 List

Ph.D. from Georgia Tech on **3D Integration of Electronics**

Reza Abbaspour, CEO

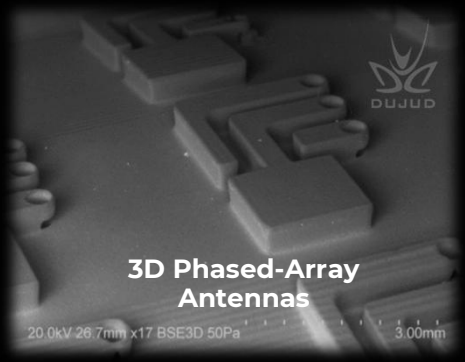


FIRST AND ONLY

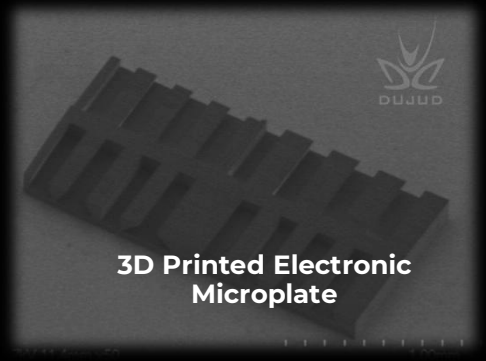
MICRO 3D SYSTEMS

- THE **FIRST** COMPANY THAT MANUFACTURES **FUNCTIONAL** **3D PRINTED** ELECTRONIC MICRO-DEVICES
- THE **ONLY** COMPANY THAT DEVELOPS **3D** PHASED-ARRAY ANTENNAS FOR THE **mmWAVE** SPECTRUM

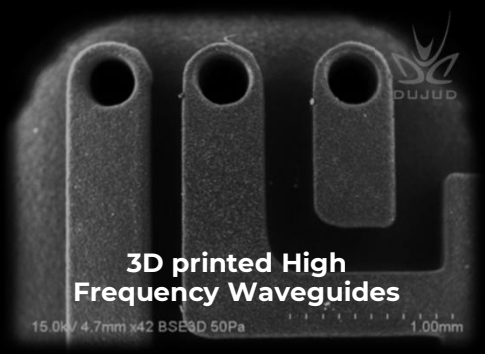
IMAGES FROM DUJUD'S MANUFACTURED DEVICES



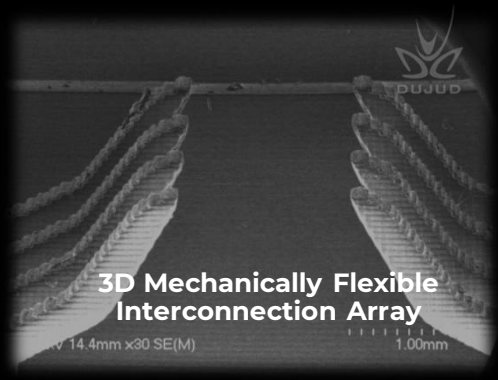
3D Phased-Array Antennas



3D Printed Electronic Microplate



3D printed High Frequency Waveguides



3D Mechanically Flexible Interconnection Array

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PROBLEM

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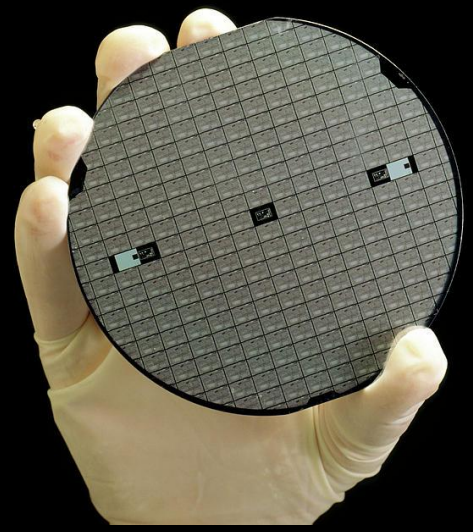
Microelectronic Industry Shortcomings

We are solving these problems



- **Slow and Costly** manufacturing process that is seen today in the national **chip shortage**
- **Complex Supply Chain** susceptible to any fluctuation increases **national security** vulnerability
- **Performance Limited** due to 70 years old 2D architecture **losing its edge** to global competitors

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TRAIL OF INNOVATIONS

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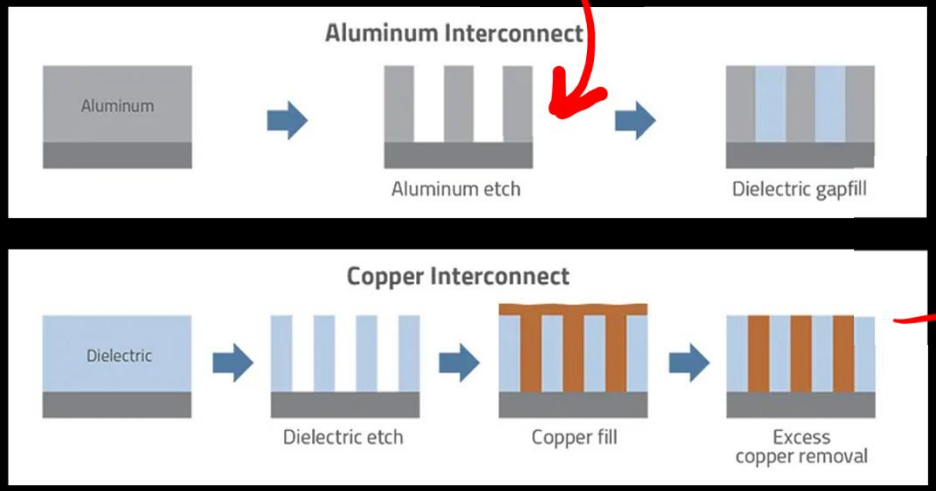
The conventional etching techniques cannot be used to pattern copper



Mechanical polishing is the key for copper patterning

White vs Orange suits

- ✗ Not compatible with cleanroom → separate facilities to avoid contamination
- ✗ Extremely expensive
- ✗ Each layer needs polishing → time consuming for 30 layers

OUR DISRUPTIVE MICROELECTRONIC TECHNOLOGY

MICRO 3D SYSTEMS

The solution is simple and specialized

- Migrating from 2D to 3D
- Moving from Subtractive to Additive Scheme

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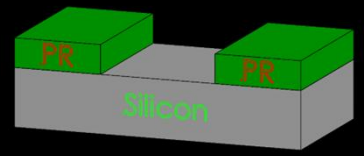
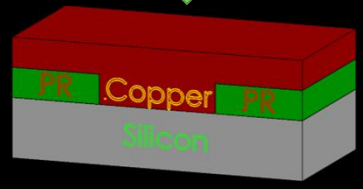
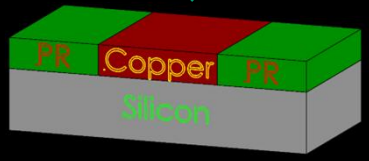
Conventional Microelectronics



Photoresist (PR) + Lithography



Copper Deposition



Mechanical Polishing (planarization)

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US011304303B2

(12) **United States Patent**
Abbaspour

(10) **Patent No.: US 11,304,303 B2**
(45) **Date of Patent: Apr. 12, 2022**

(54) **METHODS AND PROCESSES FOR FORMING ELECTRICAL CIRCUITRIES ON THREE-DIMENSIONAL GEOMETRIES**

(71) Applicant: **DUJUD LLC**, Atlanta, GA (US)

(72) Inventor: **Reza Abbaspour**, Marietta, GA (US)

(73) Assignee: **DUJUD LLC**, Atlanta, GA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **17/244,399**

(22) Filed: **Apr. 29, 2021**

(65) **Prior Publication Data**

US 2021/0345494 A1 Nov. 4, 2021

Related U.S. Application Data

(60) Provisional application No. 63/018,001, filed on Apr. 30, 2020.

(51) **Int. Cl.**
H05K 3/12 (2006.01)
H05K 3/46 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H05K 3/1258*** (2013.01); ***H05K 3/043*** (2013.01); ***H05K 3/1275*** (2013.01); ***H05K 3/4664*** (2013.01); *B33Y 10/00* (2014.12); *B33Y 30/00* (2014.12); *B33Y 80/00* (2014.12); *H05K 3/0011* (2013.01); *H05K 3/0014* (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H05K 3/043; H05K 3/1258; H05K 3/1275; H05K 3/4626; H05K 3/4632; H05K 3/4635; H05K 3/4644; H05K 2203/1338; H05K 2203/135; H05K 2203/1355; H05K 3/143; H05K 3/284; H05K 3/4664; H05K 3/4652; H05K 3/467; H05K 2203/0574; H05K 2203/0588; H05K 2203/1184;
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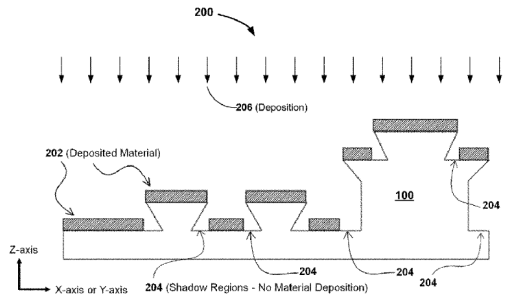
Primary Examiner — A. Dexter Tugbang
(74) *Attorney, Agent, or Firm* — Troutman Pepper Hamilton Sanders LLP; Mark Lehi Jones

(57) **ABSTRACT**

Methods for forming electrical circuitries on three-dimensional (3D) structures and devices made using the methods. A method includes forming selectively shaped 3D structures using additive manufacturing. The method includes forming undercuts on upper-level pedestals of the 3D structures that effectively act as overhanging deposition masks for selectively preventing deposition of a selected material on a corresponding portions of lower levels. The method includes simultaneously forming and electrically isolating materials directionally deposited on the 3D structure.

16 Claims, 5 Drawing Sheets



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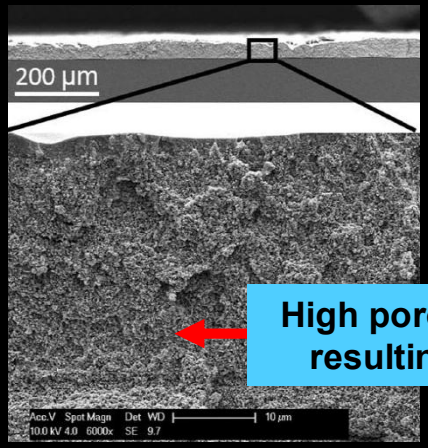
COMPETITIVE PERFORMANCE METRICS

MICRO 3D SYSTEMS

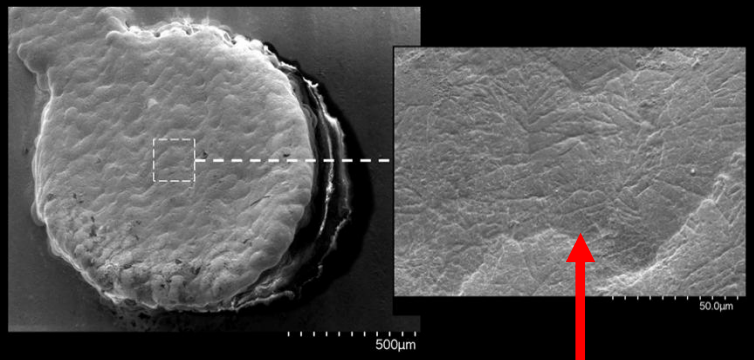
INK/AEROSOL-JET DEPOSITION PRINTING vs DUJUD FLASH 3D PRINTING

- ✖ 2D process by nature → challenging to employ on 3D surfaces
- ✖ High porosity → poor electrical conductivity
- ✖ Low adhesion to substrate → low mechanical reliability
- ✖ Sequential process → time consuming and difficult to scale
- ✖ Material limited → requires fluid bonding agents



High porosity profile (low quality) resulting from ink-jet printing ✖

- ✔ A True 3D process → virtually any 3D geometry can be manufactured
- ✔ Dense metal formation → 90% of bulk electrical conductivity
- ✔ High adhesion to substrate → the same quality metric that is achieved by the semiconductor industry
- ✔ Instantaneous process → The reason that its FLASH. It enables mass manufacturing because of high speed printing
- ✔ Virtually all dielectrics and metals are available



Smooth and dense metal profile resulting from our FLASH 3D PRINTING Technology ✔

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COMPETITIVE PERFORMANCE METRICS

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HIGH PRECISION MANUFCATURING

MICRO 3D SYSTEMS

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HIGH PRECISION MANUFCATURING

MICRO 3D SYSTEMS

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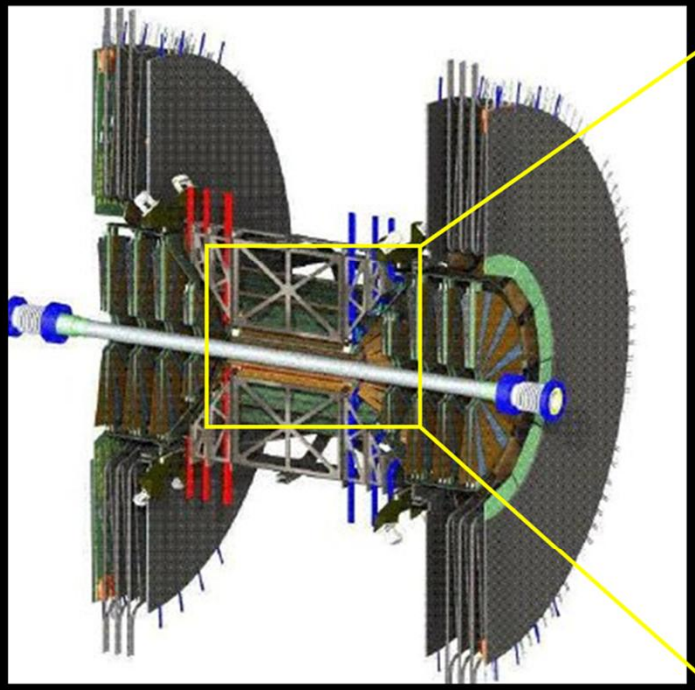
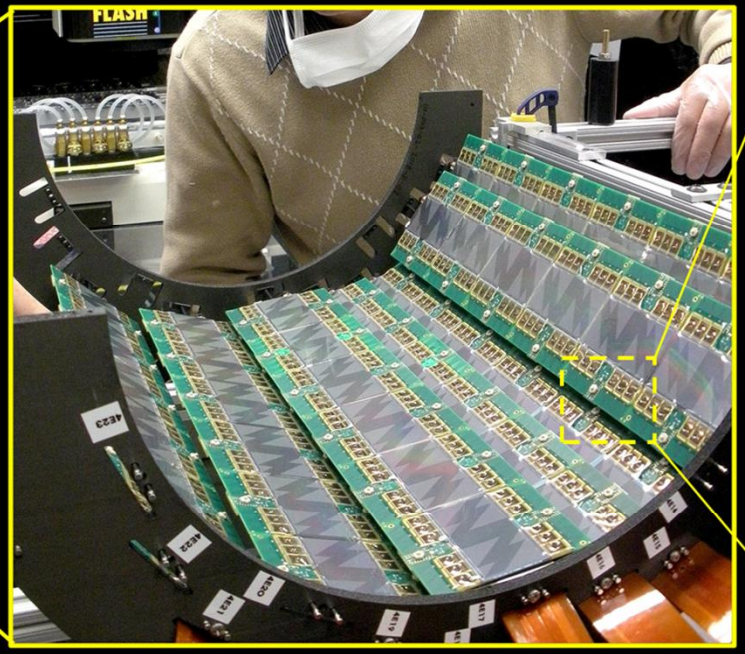
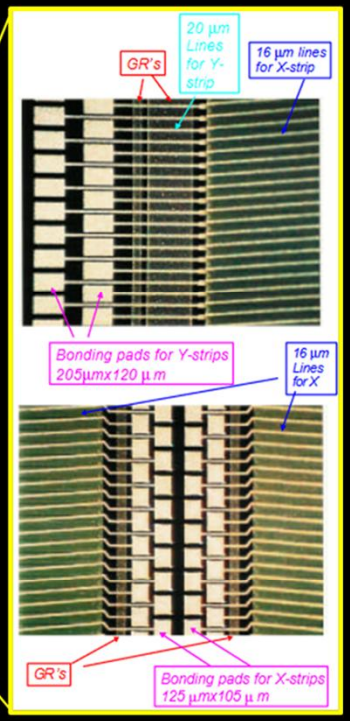
PARTICLE ACCELERATORS

MICRO 3D SYSTEMS







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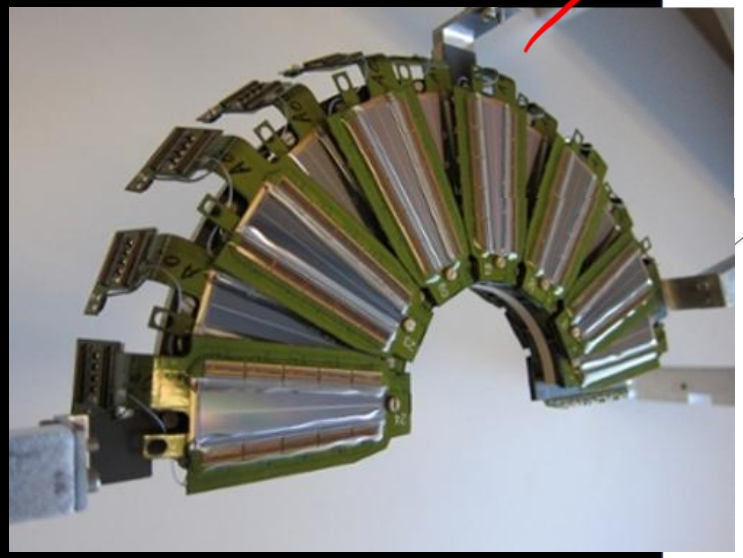
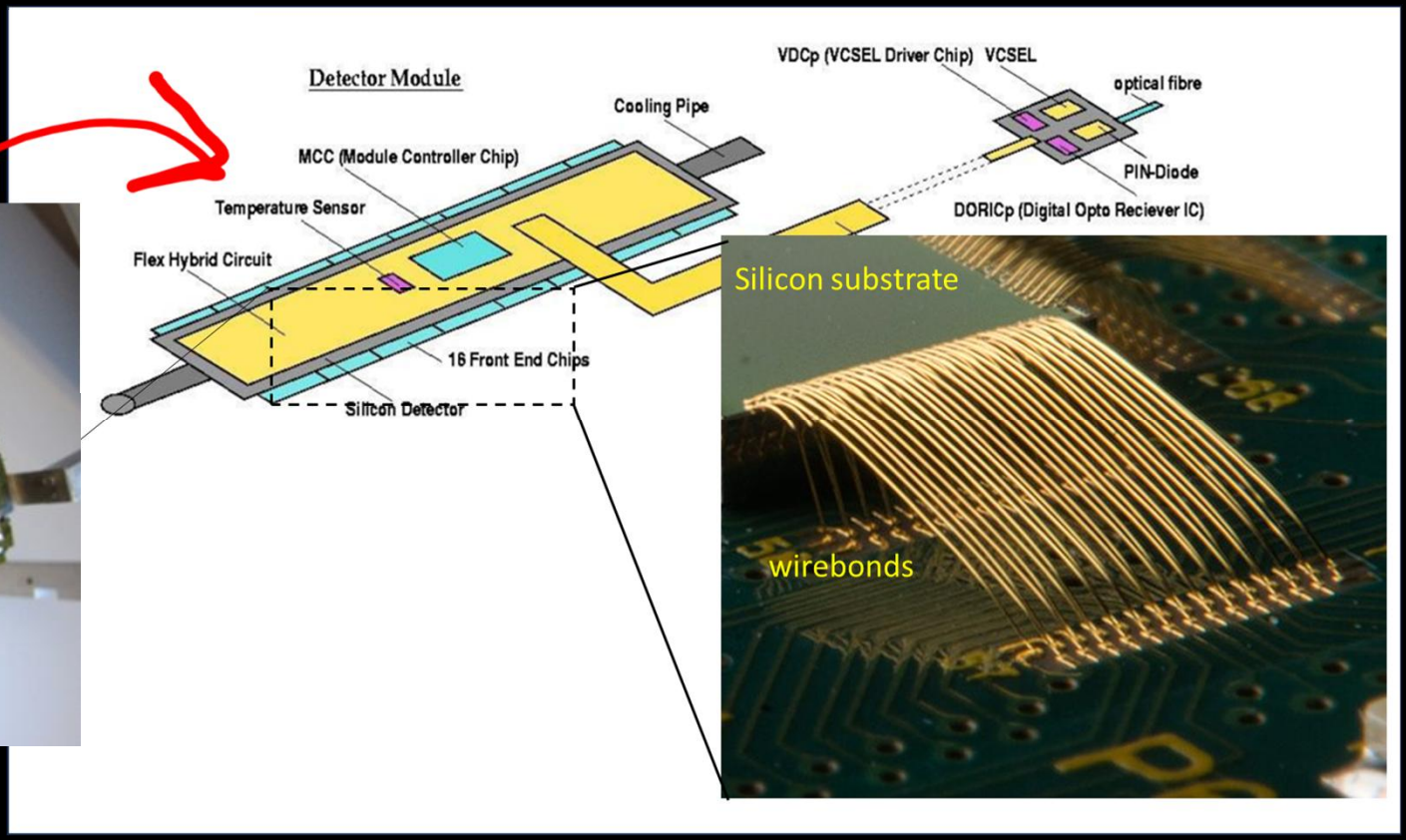
PROBLEM: PERMANENT BONDS

MICRO 3D SYSTEMS





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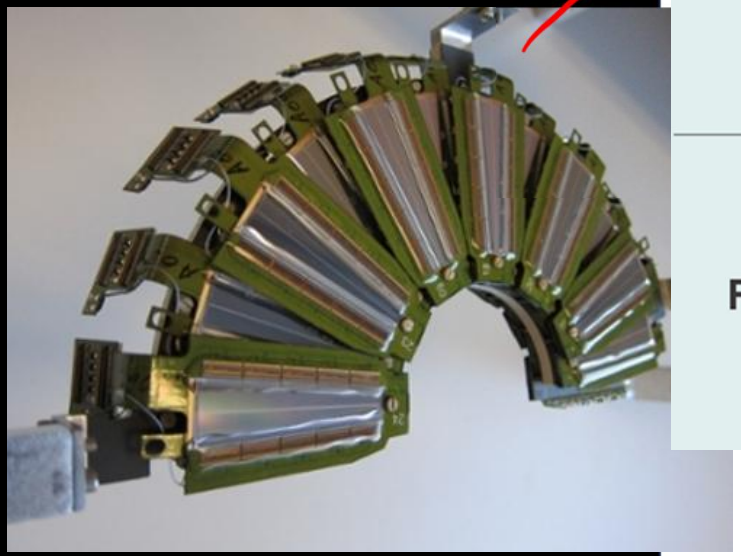

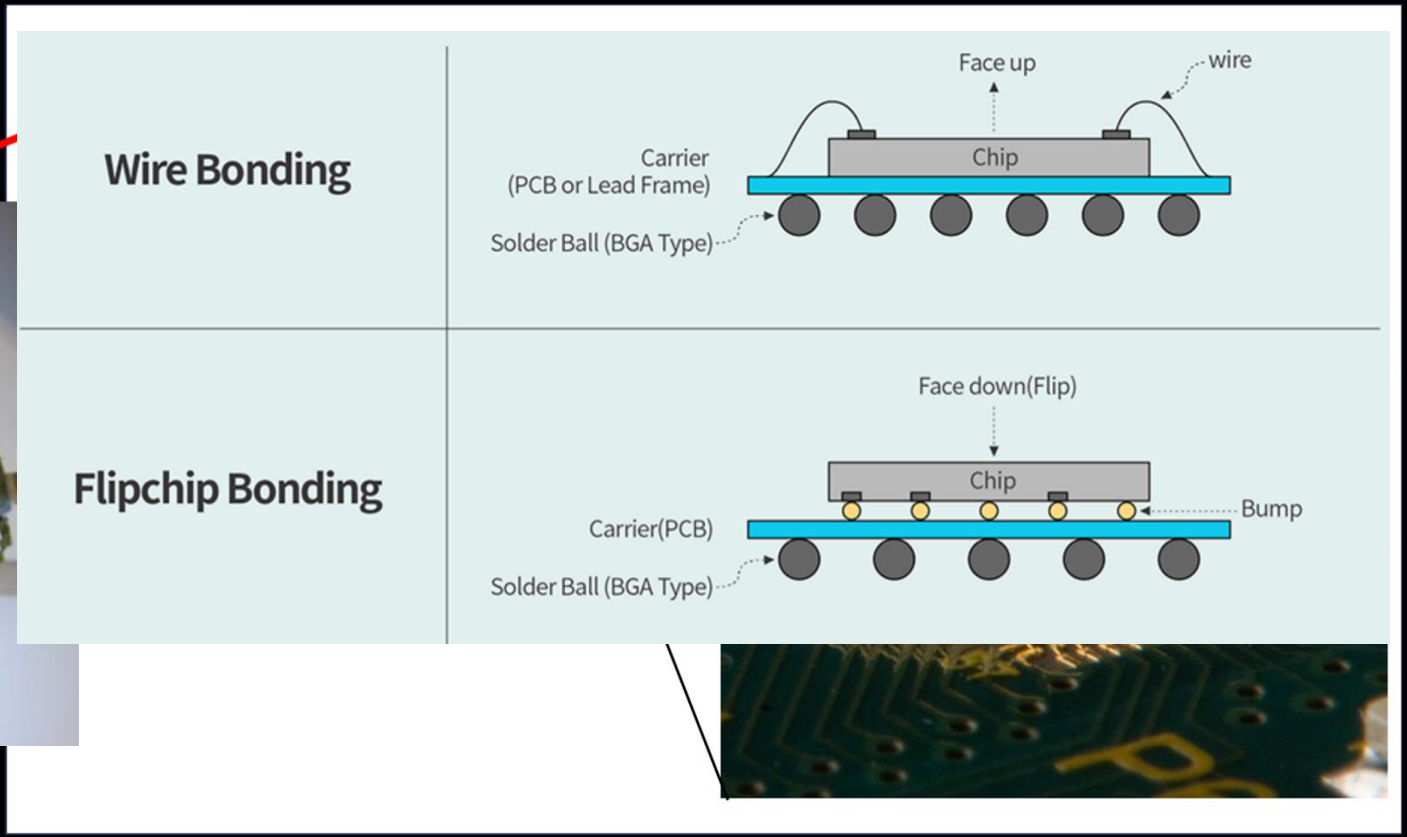

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3D FLEXIBLE INTERCONNECTION (3FI)

MICRO 3D SYSTEMS

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3D FLEXIBLE INTERCONNECTION (3FI)

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3D FLEXIBLE INTERCONNECTION (3FI)

MICRO 3D SYSTEMS

Masked Intentionally

3D FLEXIBLE INTERCONNECTION (3FI)

MICRO 3D SYSTEMS

Masked Intentionally

3D PRINTED SiP

MICRO 3D SYSTEMS

Masked Intentionally

SiP- CIRCUMVENTING SOLDER BALLS

MICRO 3D SYSTEMS

Masked Intentionally

SiP- CIRCUMVENTING SOLDER BALLS

MICRO 3D SYSTEMS

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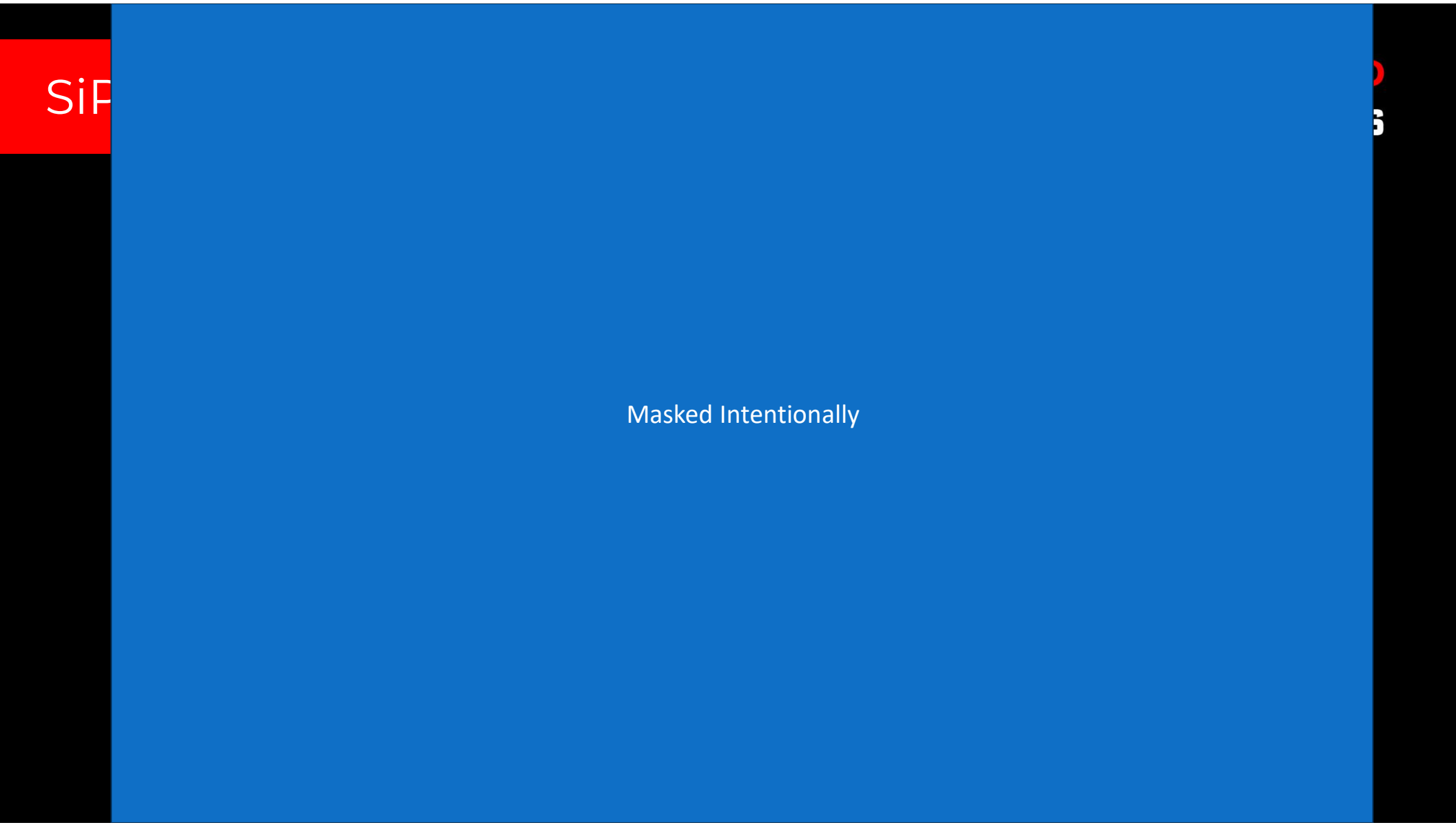
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SiP- MULTI CHIP MICROSYSTEM

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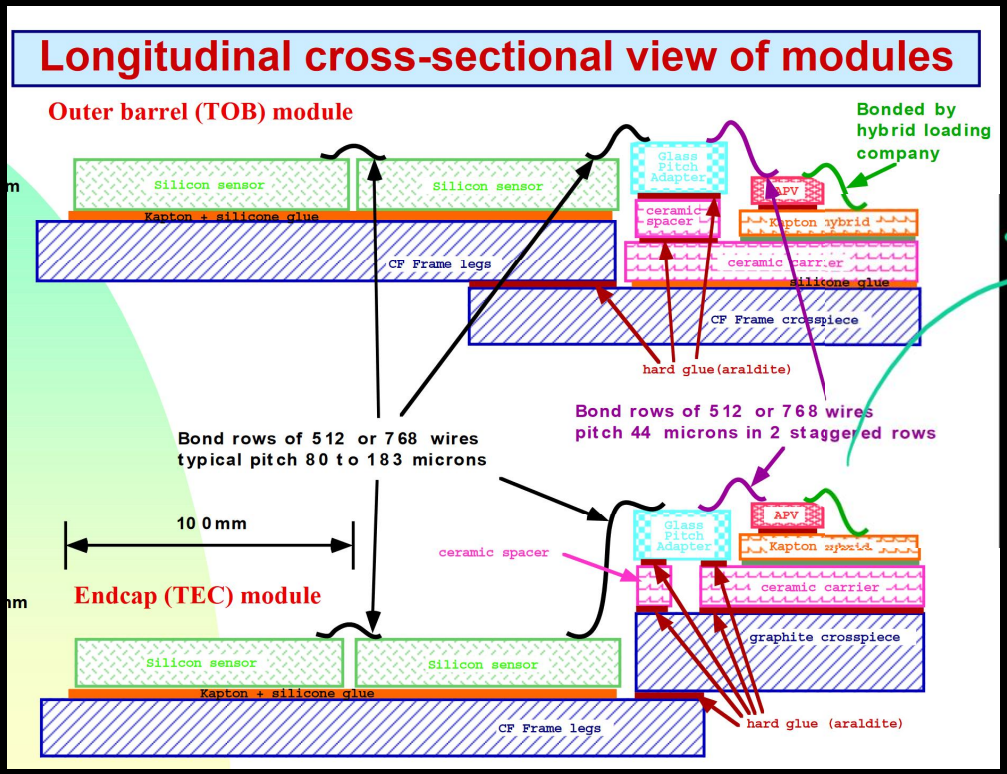
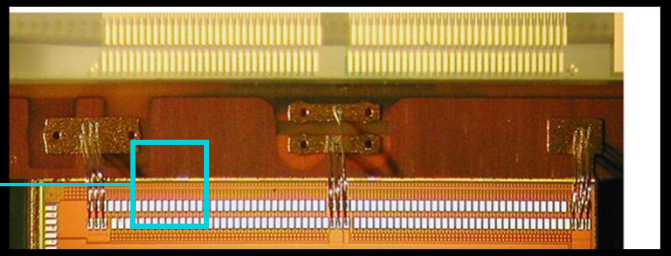
BRIDGE- CIRCUMVENTING WIREBOND

MICRO 3D SYSTEMS





BRIDGE- CIRCUMVENTING WIREBOND

MICRO 3D SYSTEMS

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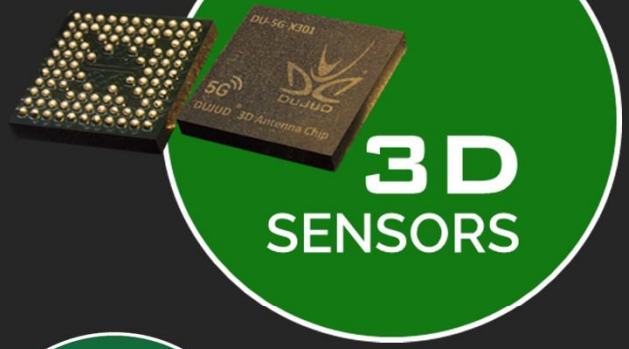
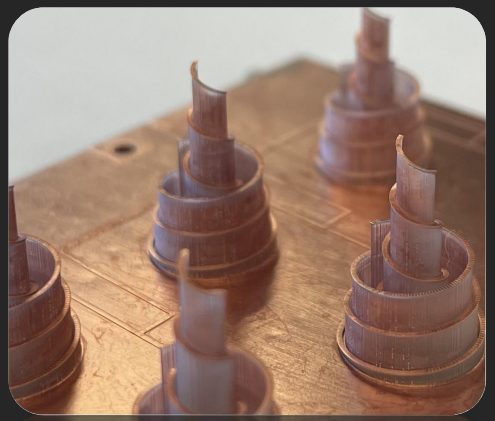
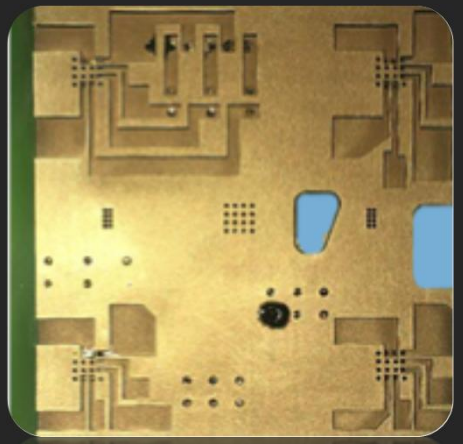
PRODUCTS

MICRO 3D SYSTEMS

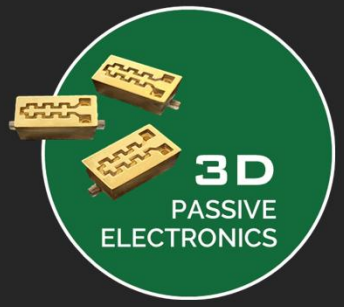


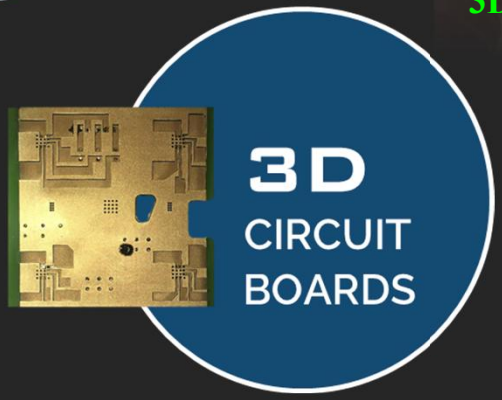


3D printed dual helical Ku-band antenna arrays



3D printed conformal but rigid circuit boards





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FOLLOW-UP QUESTIONS

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