

# NASA Guidelines BGA/DSBGA

(Ball Grid Array/Die Size BGA)

by

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<http://nepp.nasa.gov>

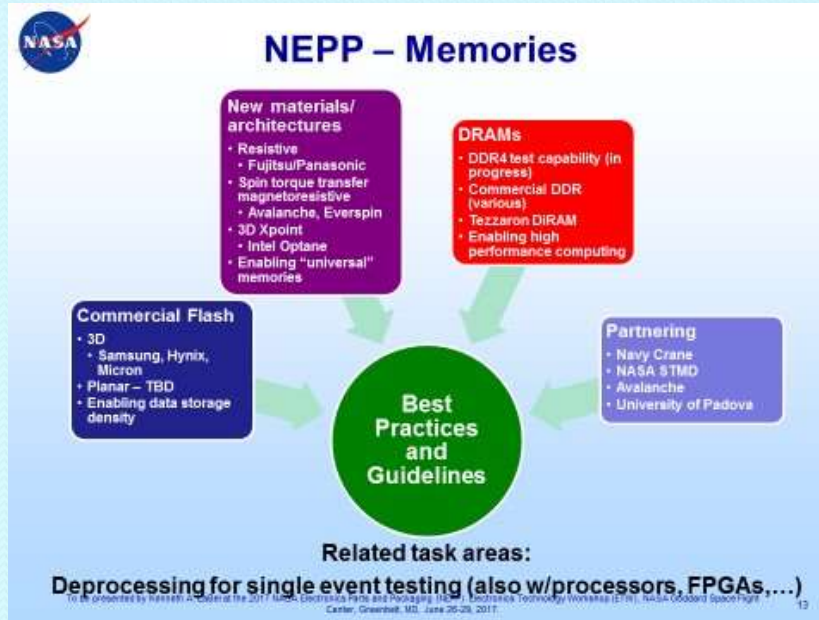


- **BGA/DSBGA Guidelines**
  - Guidelines document on NEPP Website
    - Previous NEPP Task on BGA
    - New under guideline NEPP task collaboration with industry for DSBGA Evaluation
    - NASA Applications
  
- **BGA, FCBGA, and 3D BGA**
  - BGA and FCBGA definition
  - BGA and FCBGA thermal cycle results and X-sections
  - 3D BGA thermal cycle results
  
- **New Test Vehicle under this Guideline for DSBGA**
  - Test vehicle design and eWLP-LGA after thermal cycles with X-section
  
- **NASA Applications**
  - MEAL: Mission, Environment, Applications, and Lifetime
  - Lessons Learned from projects, NEPP, NESC, Literature
  - Lessons learned for part and PCB
  - Lessons learned for assembly
  - MEALs for NASA-wide projects
  - Step by Step for MEAL implementation
  - Brief discussion on HALT and HASS for COTS BGA/DSBGA
  
- **Summary**

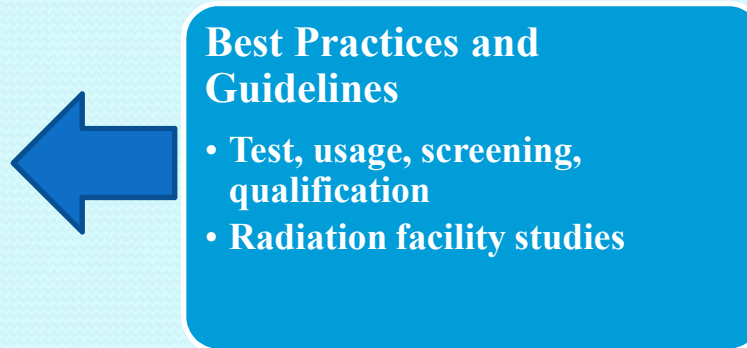


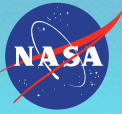
# BGA/DSBGA & Guidelines

## Electronics Packaging Evaluation



**Guidelines  
on  
NEPP  
Website**





## Guidelines on BGA/DSBA & Use

*BGAs*  
*FCBGA/3D*  
*NEPP Test Results*

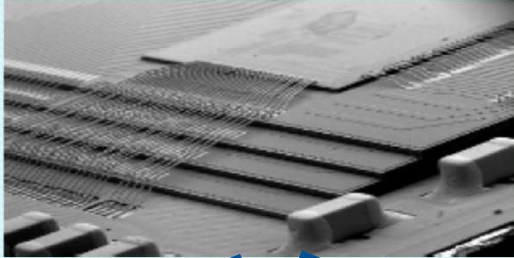
DSBGA  
eWLP/LGA  
New NEPP Test  
Results

*NASA Applications*  
*Part/Assembly/MEAL*



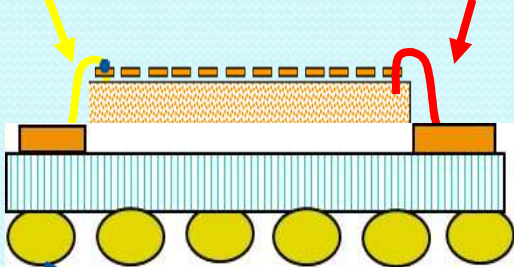
# BGA/DSBGA Guideline

## BGA with Internal Wire Bond



Gold Wire

Cu-Wire



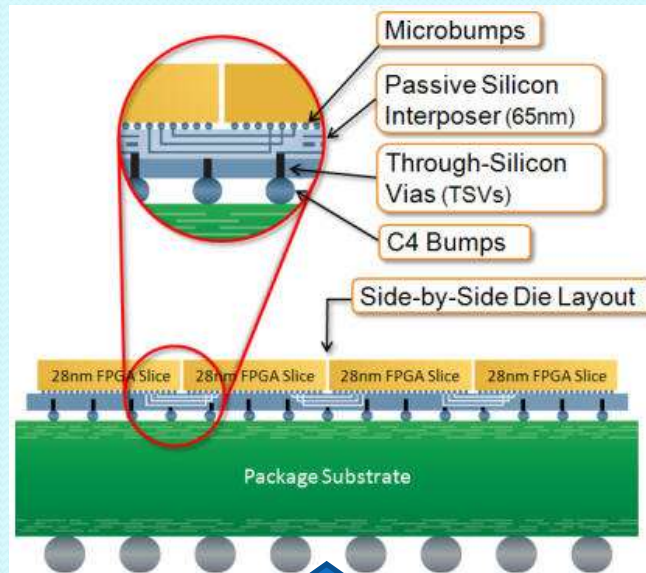
Tin Lead or Lead-free Balls



Printed Circuit Board (PCB)

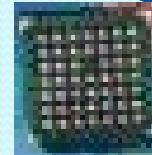
NEPP ETW-2022

Flip-Chip BGA (FCBGA)  
Internal and External  
Balls or Copper Pillar

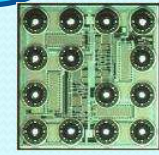


Tin Lead or Lead-free Balls

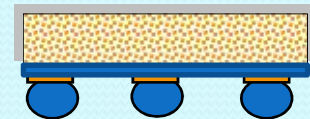
DSBGA  
CSP/WLP/  
FOWLP



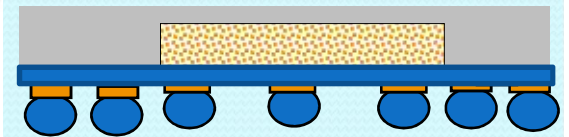
Chip Scale  
Package  
(CSP)



Wafer Level  
Package  
WLP



WLP



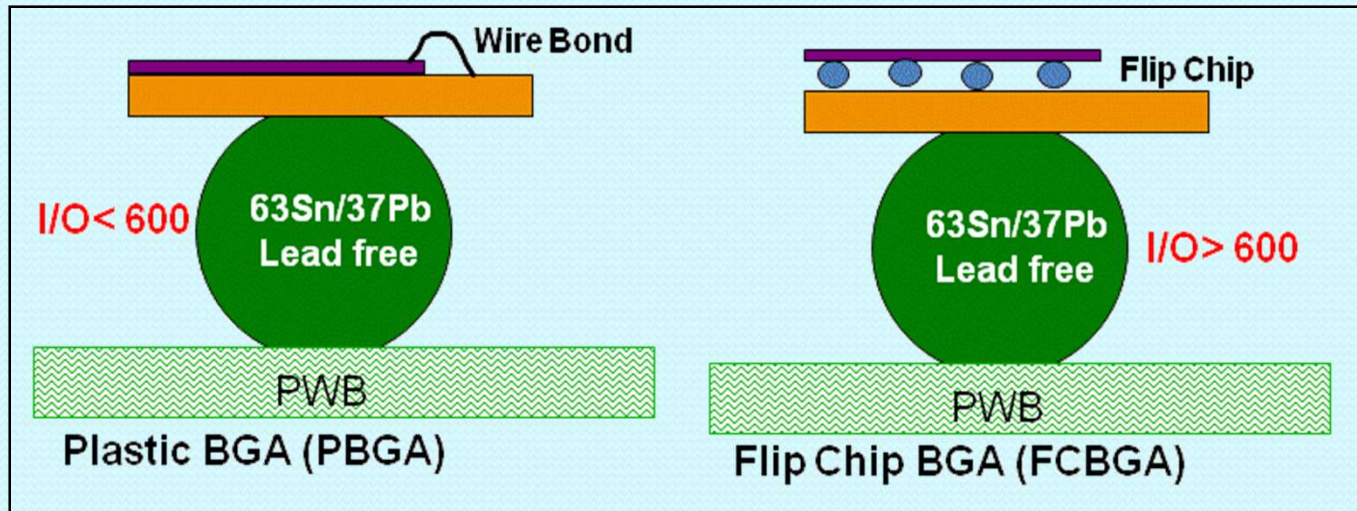
FOWLP

Lead-free Balls or Land

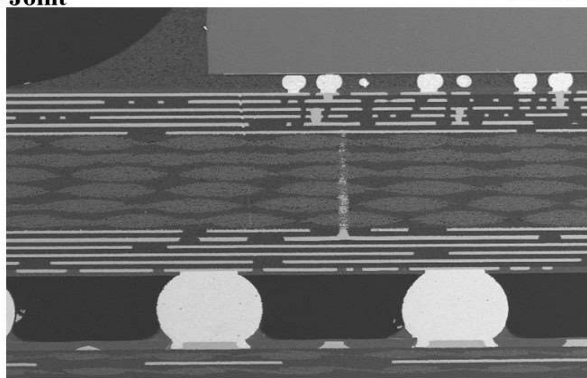
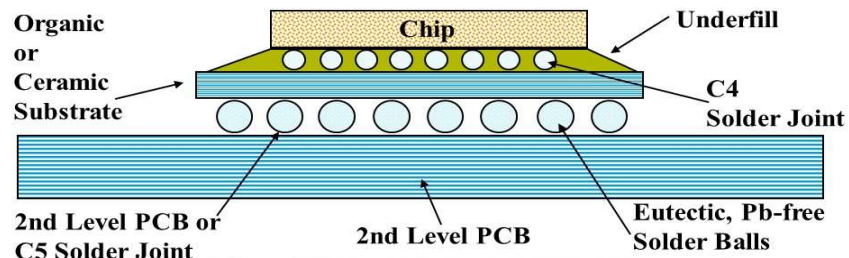
Reza Ghaffarian



# BGA & FCBGA



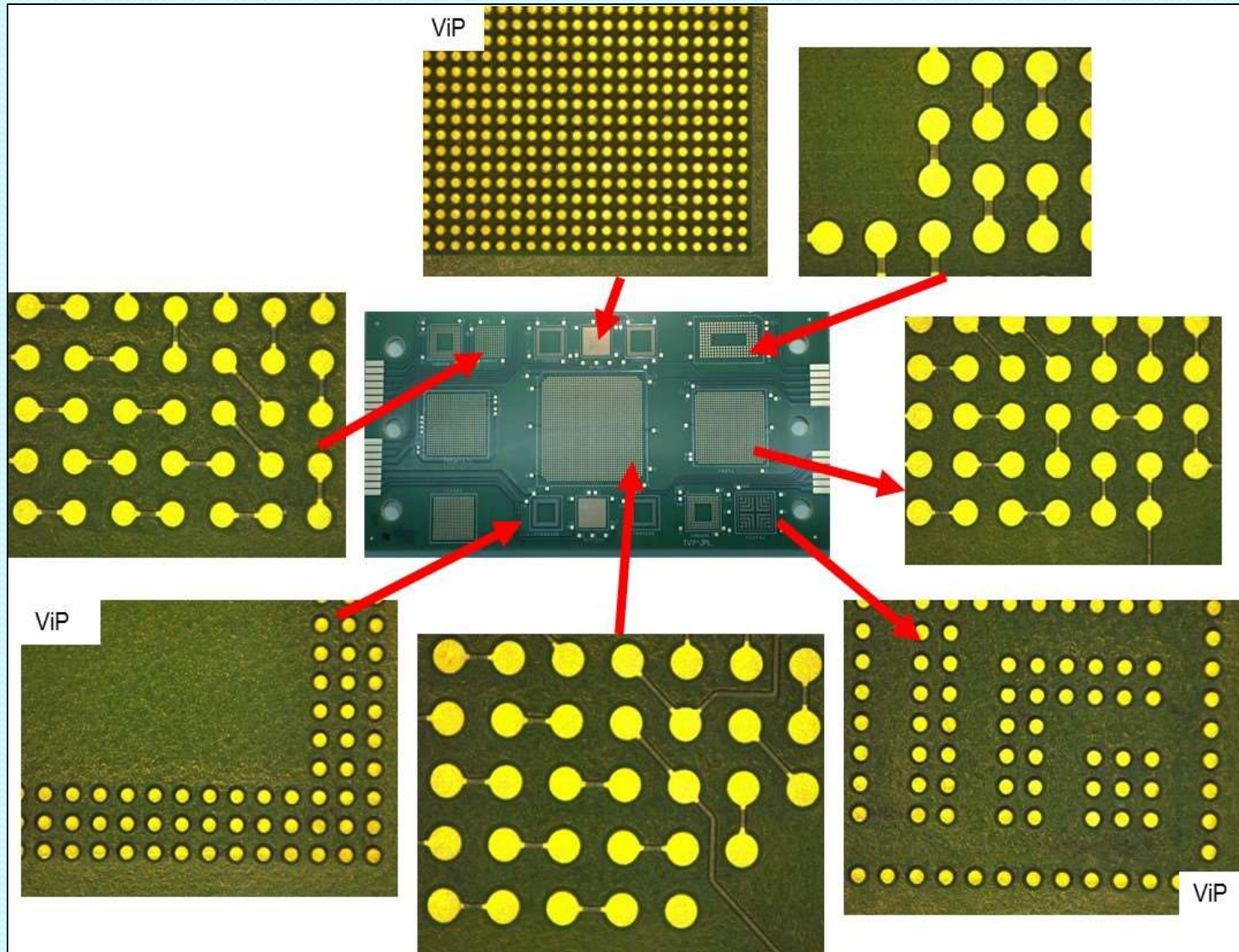
## Flip-Chip BGA (FCBGA)





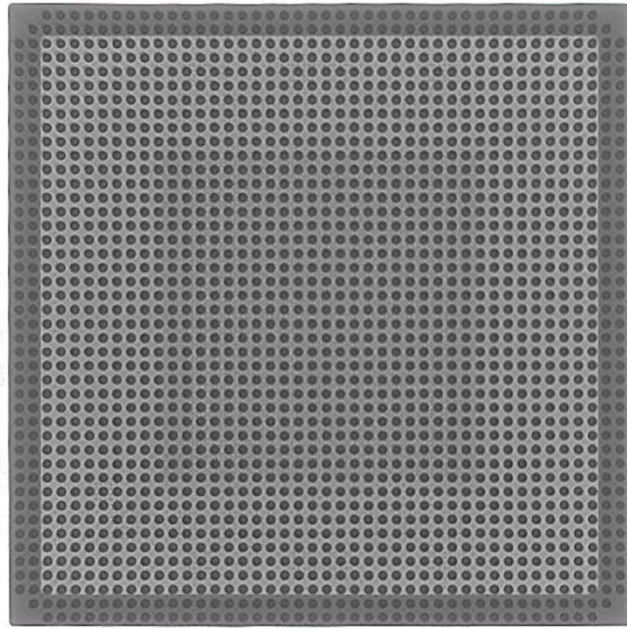
# NEPP BGA FCBGA Test Results

## Lessons Learned

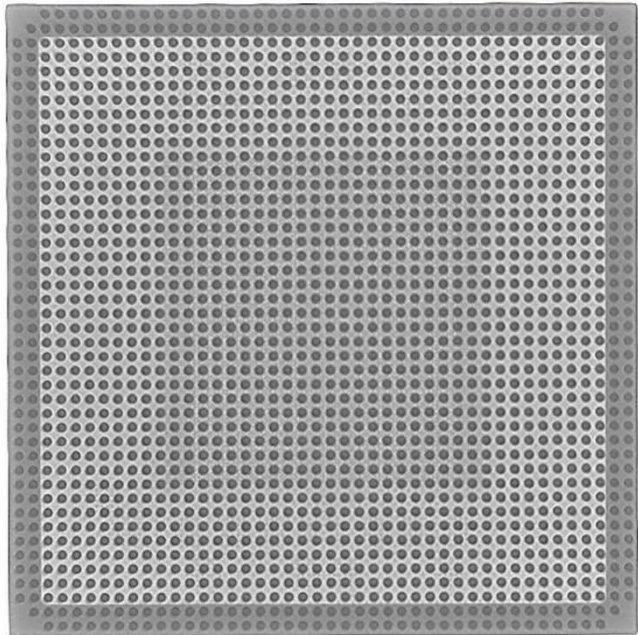
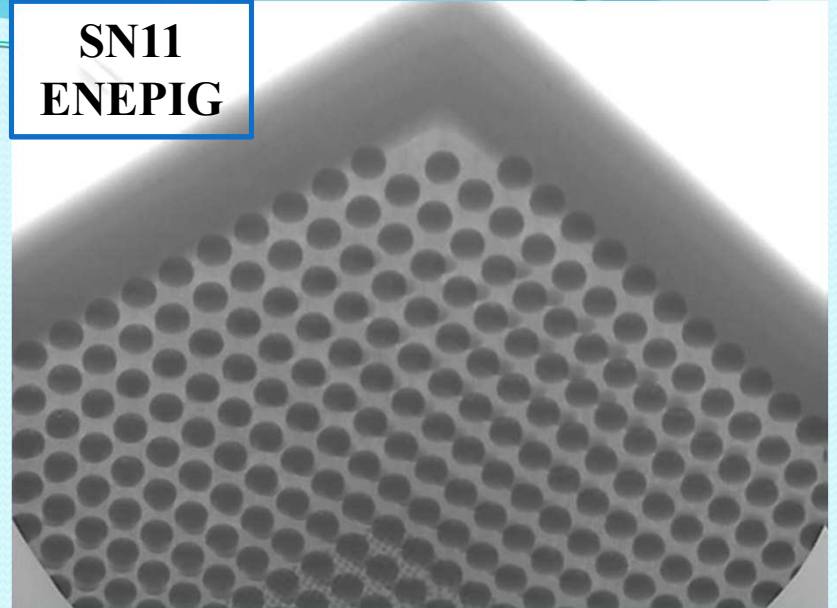




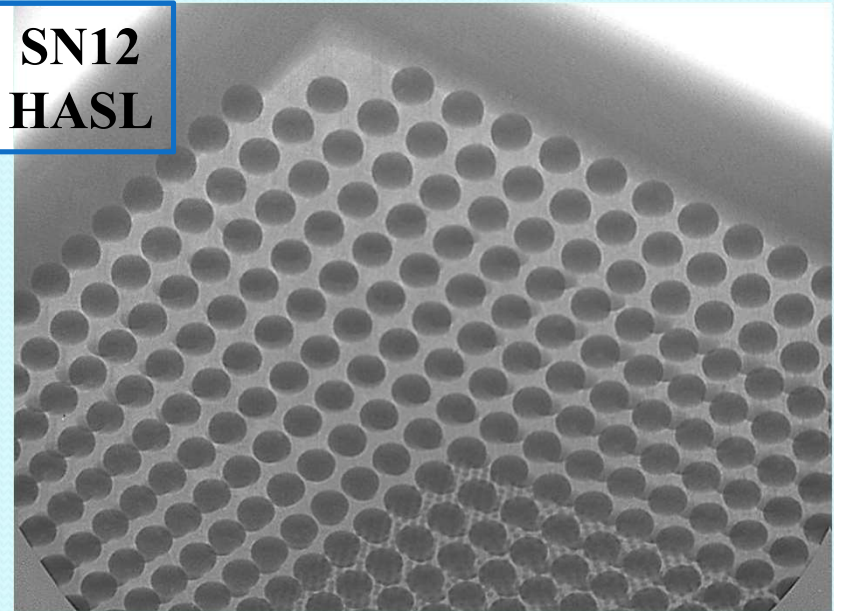
# X-ray FCBGA 1924



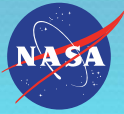
**SN11  
ENEPIG**



**SN12  
HASL**

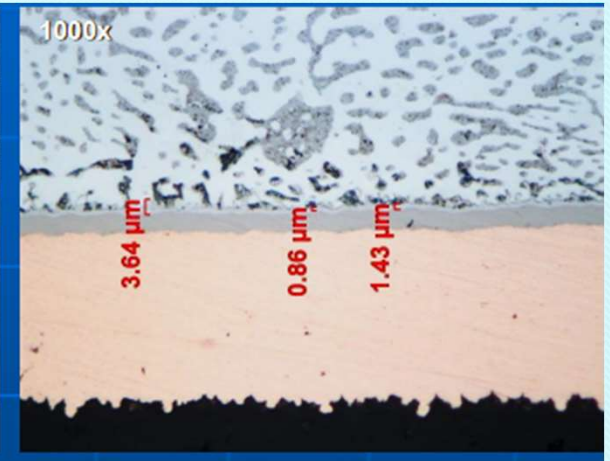
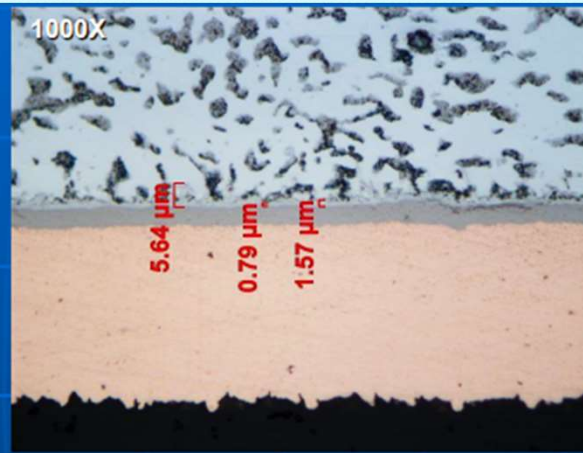
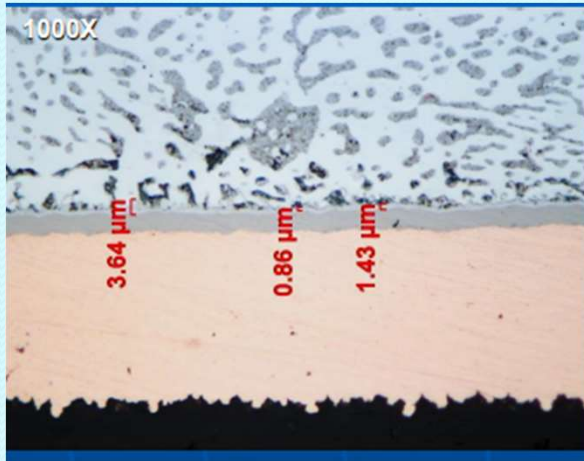
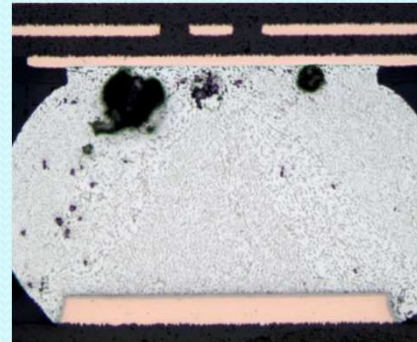
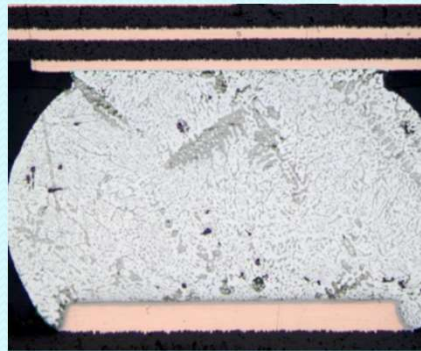
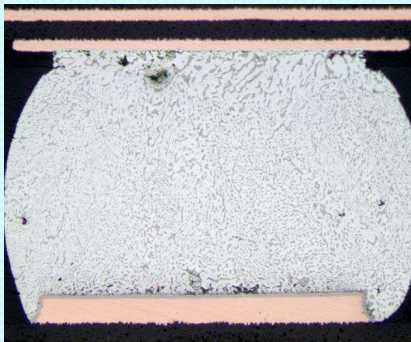






# FCBGA 1924 on ENEPIG

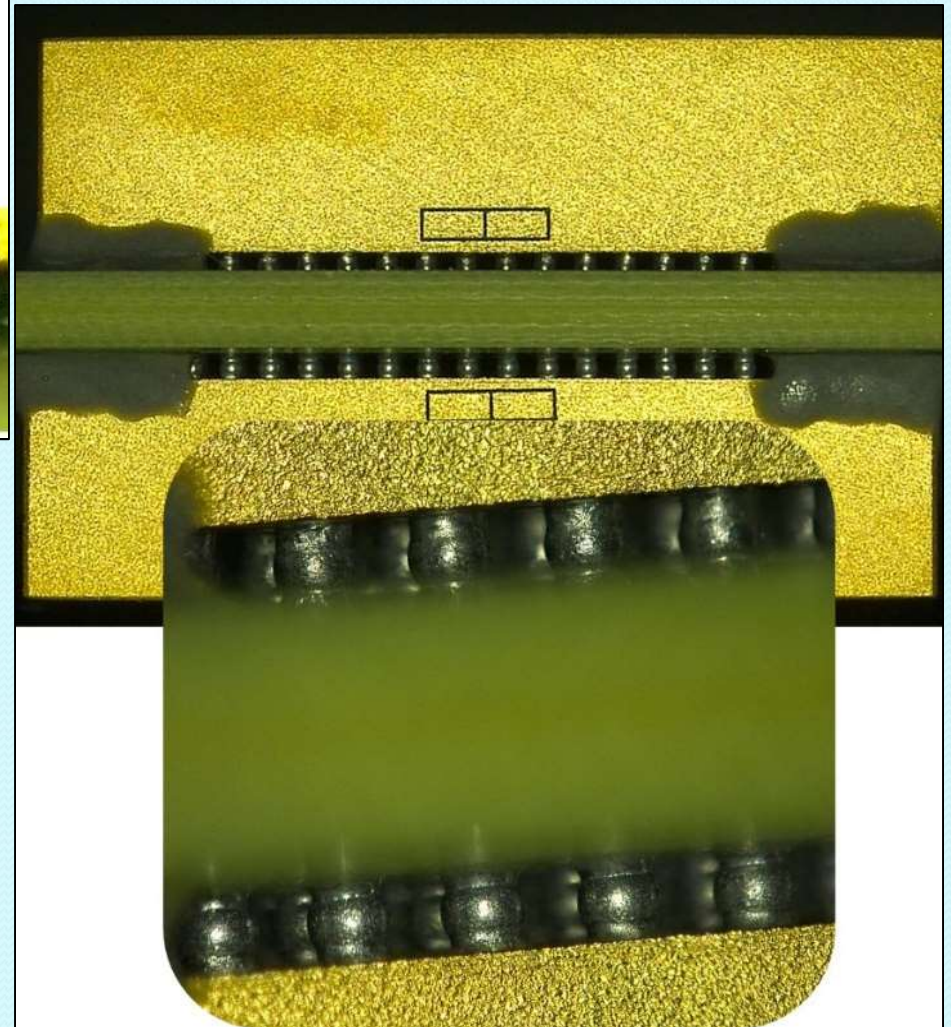
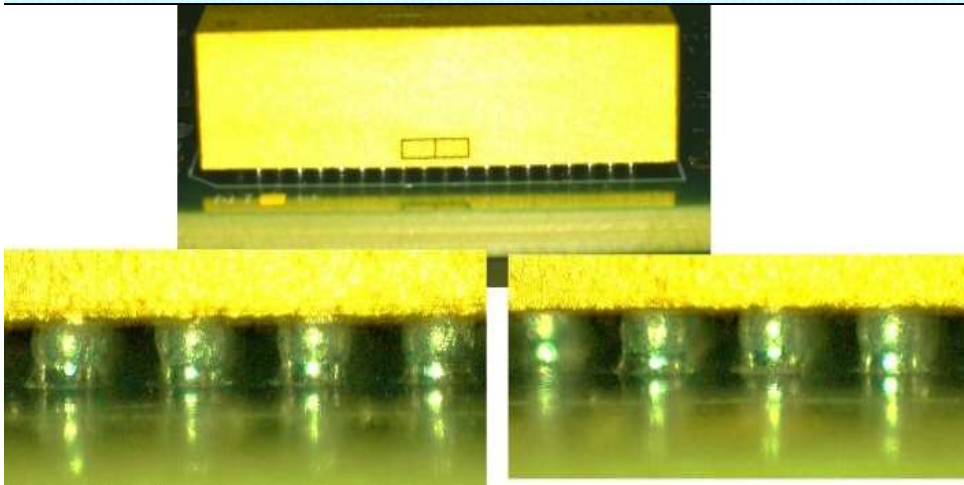
## 200 TSC (-65°C/150°C)





# 3D BGA Stack

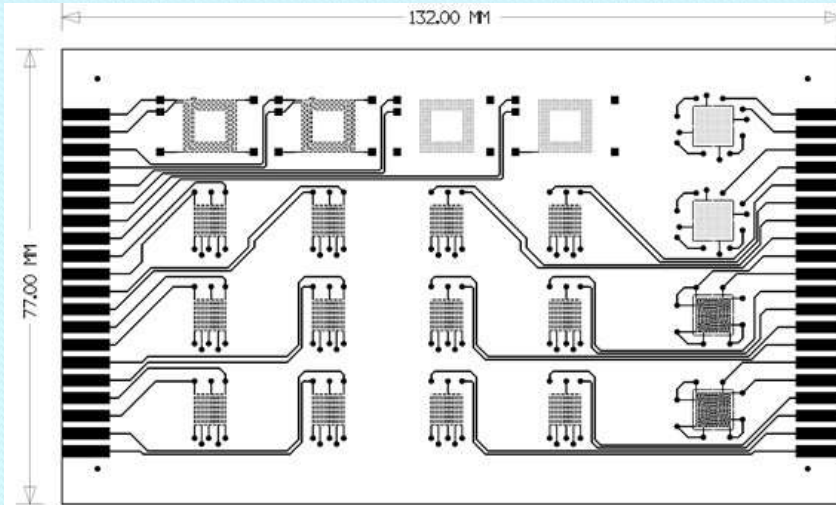
200TCs (-55/100°C), Single- & Double-Sides





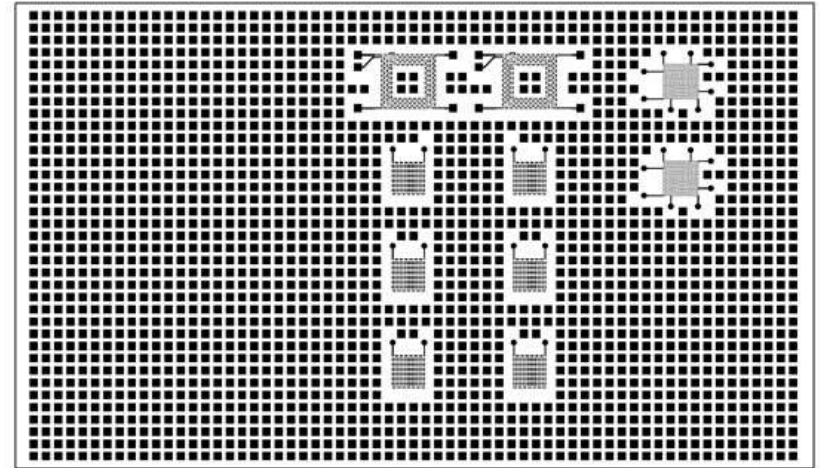
# NEW: NEPP DSBGA Test Results

## Lessons Learned

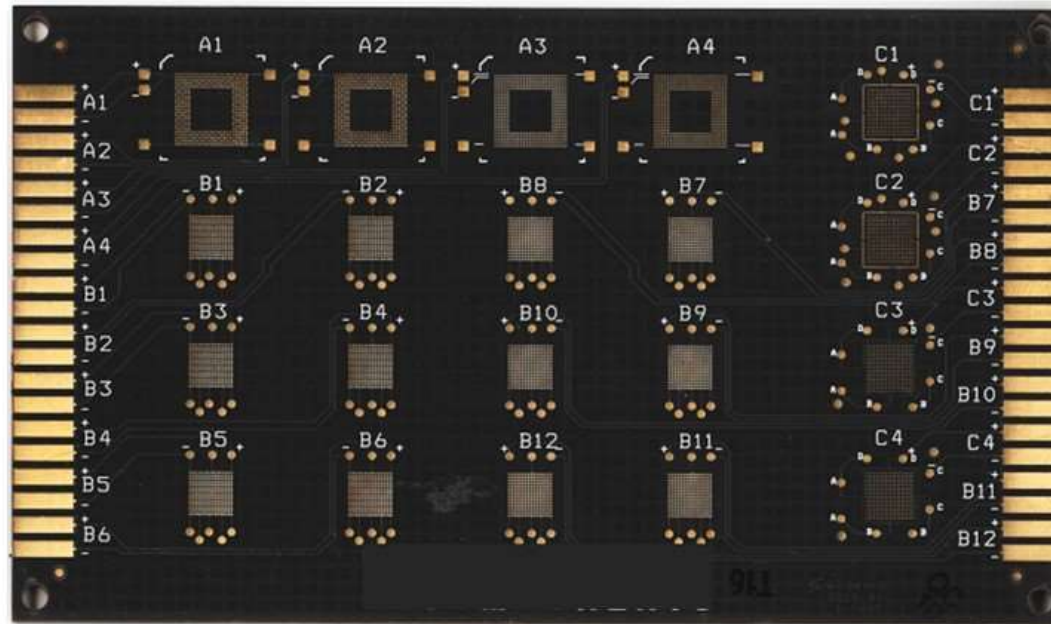


ALL LAYERS VIEWED FROM LAYER 1

LAYER 1

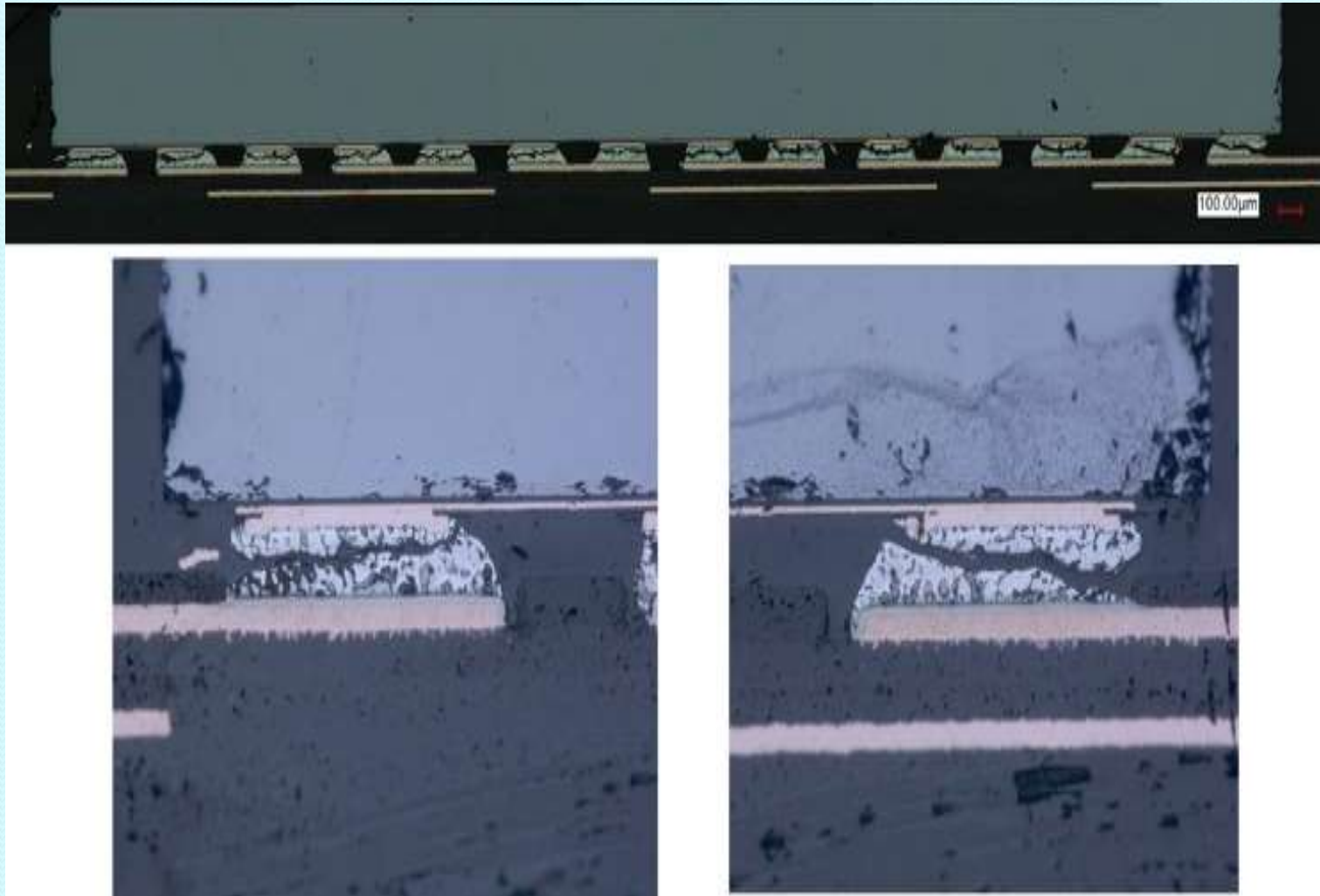


ALL LAYERS VIEWED FROM LAYER 1 LAYER 2





# DSBGA:eWLP LGA TC Test Results (-40/125C)



Representative micro-section images showing early failure of eWLP-LGA at B2 location of Bar Code 713651 PWA removed after 951 cycles and X-sectioned.

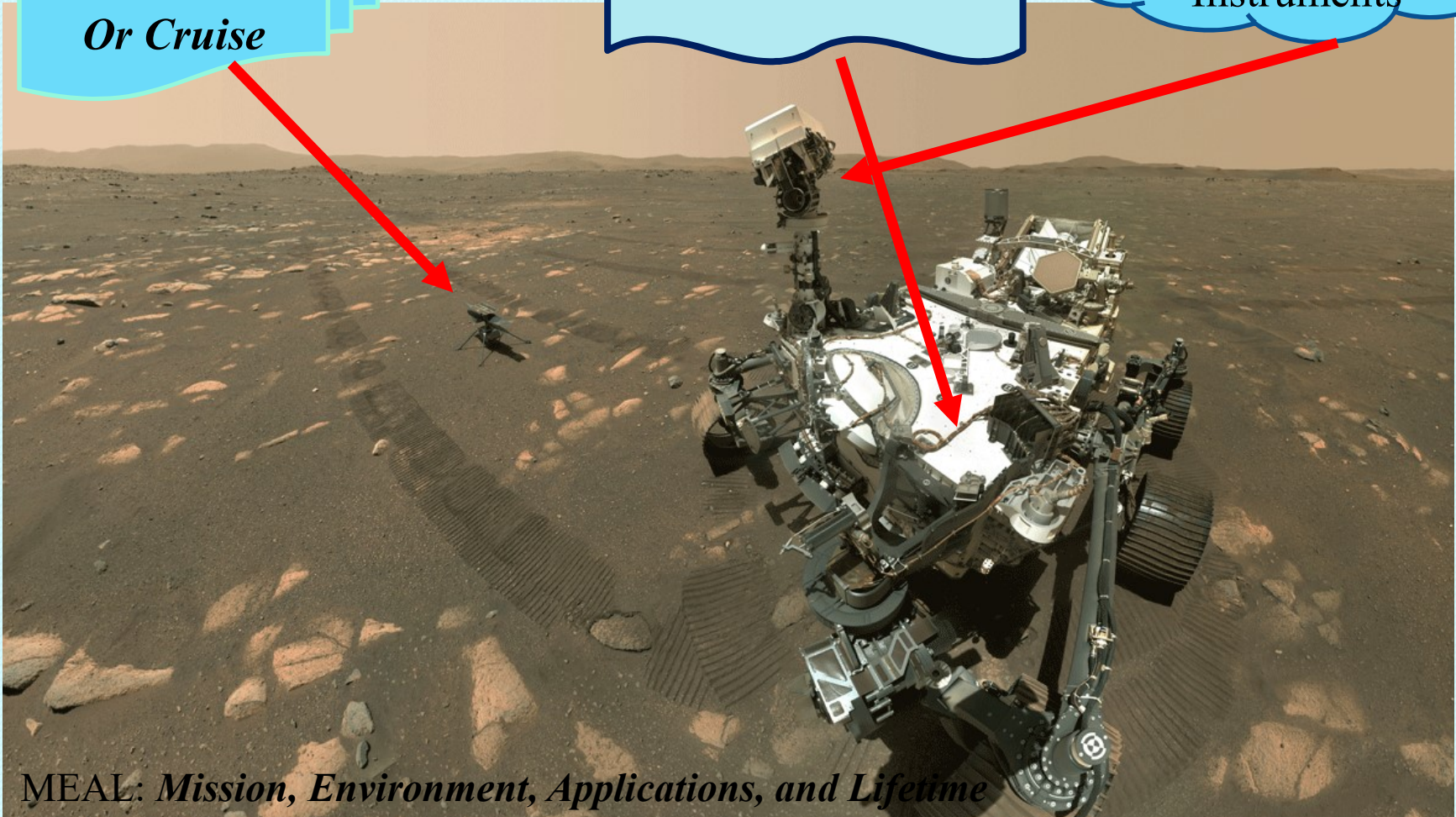


# Various MEALs

*Technology  
Demonstration  
Or Cruise*

*Control MEAL  
Rover*

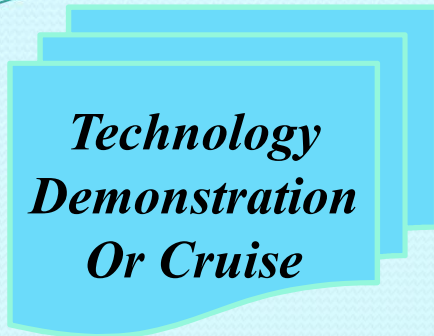
Extreme MEAL  
Rover &  
Instruments



MEAL: *Mission, Environment, Applications, and Lifetime*



# BGA/DSBA Guidelines Rover MEALs



## Helicopter VCE

- ❖ BGAs
  - ✓ Meet MEAL
- ❖ DSBGAs
  - ✓ Possibly meet MEAL

Corner filling or full underfill may be required



## Avionics

- BGAS
  - ✓ Possibly meet MEAL
- DSBGAs
  - ✓ May be meet

Corner filling for BGAs  
full underfill for DSBGAs



## Cameras Instruments

- BGAS
  - ✓ Must be qualified for MEAL
- DSBGAs
  - ✓ Do not meet MEAL

Corner filling or full underfilling for BGAs  
Do not use DSBGA



# Summary

## ➤ **NASA BGA/DSBGA Guidelines**

- Summary of Previous NEPP Evaluation & Test Results for BGA/FCBGA/3D BGA
- Summary of New NEPP Evaluation & Test Results for DSBGA, e.g., eWLP BGA and LGA
- NASA Applications MEALs
  - Lessons Learned from projects, NEPP, NESC, and /Literature review

## ➤ **Key Recommendations**

- Narrow potential COTS packaging technologies and types using supplier data and application notes.
- Review build up, materials, solder geometry and solder alloys (internal or external), heat distribution, etc.
- Review moisture sensitivity and bake out recommendation. Review non-standard PCB technologies for MEAL since a number of modifications are required to accommodate BGAs and especially DSBGAs.
- Use a daisy-chain package as the test article for assembly verification and accelerated thermal cycle tests per industry standards. Include double-sided assembly if applicable.

## ➤ **Future Work**

- NASA Project implementation increased on COTS advanced packaging BGA technologies
- No NEPP funds for continuation on COTS BGA/DSBGA & Evaluation
- Recommend NEPP's attention on this critical packaging technologies



# Acknowledgment

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The author would like to acknowledge the support of the JPL team and industry/university partners. The authors also extend their appreciation to the program managers of the National Aeronautics and Space Administration Electronics Parts and Packaging (NEPP) Program.

## Thank



M2020 Perseverance  
Mission Status  
Rover Odometry:  
11128.64 meters, Rover  
Samples: 8 rock cores,  
1 atmospheric sample,  
1 witness tube  
Helicopter Log: 28  
flights, 6909 m, 3254.9  
sec

**Image of the day:**  
*Post-drive NavCam  
image from sol 428  
(email 5/4/2022)*