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Prototyping IoT modules and assembling by additive manufacturing

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DEVICE PACKAGING

Outline

- Background and Motivation
- Technical Challenges
- Motif data
- Results
- Conclusions

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IoT market trends

Variety & Flexibility
- **Function, size, shape, quantity**

Product life cycle is typically shorter

Source of reference: Trillion-Node Study Group https://www.trillion-node.org/

Quick prototype creation from product ideas is required.

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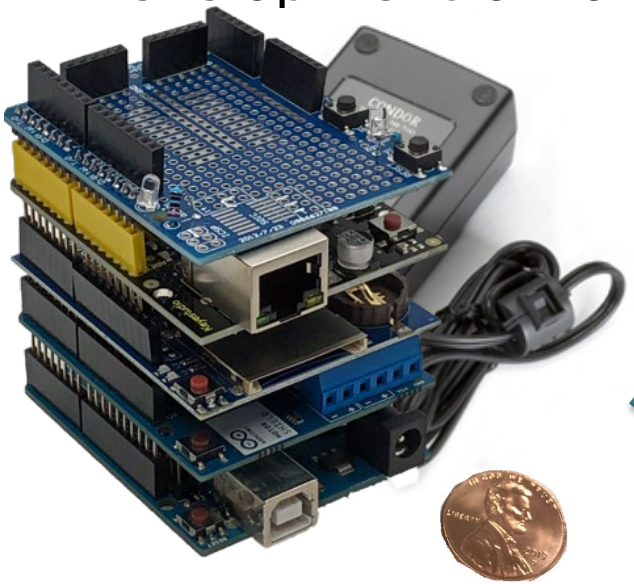
Concept of “Leafony”

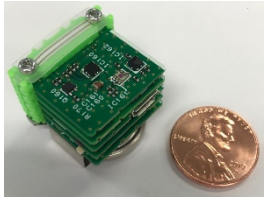
- Development of IoT module assembled without soldering



Conventional module

- Compact size: 1/100th volume
- Low-power : 1/10th power consumption
- Time to market of 1/10th

Open source hardware/software
Open documents
Easy to assemble
Easy to manufacture leaf substrate



Leafony

Source of reference: Trillion-Node Study Group https://www.trillion-node.org/

- Create, expand & cultivate IoT market with Makers
- Help industries achieve short TAT, easy and low-cost access to market

Anyone can design
Anyone can manufacture prototype

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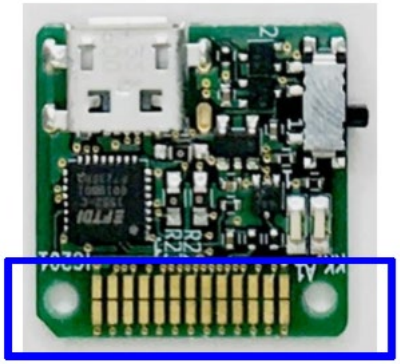
Technical scheme & assembly variation of Leafony

Technical scheme

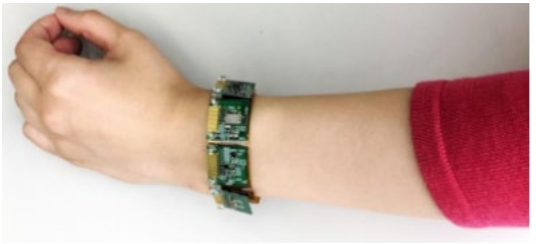


Leaf
common ex.29-pins I/F

Leaves in 3D assembled with bolts

Assembly variation

Stacking type (standard)



Application of flat type

Source of reference: Trillion-Node Study Group https://www.trillion-node.org/

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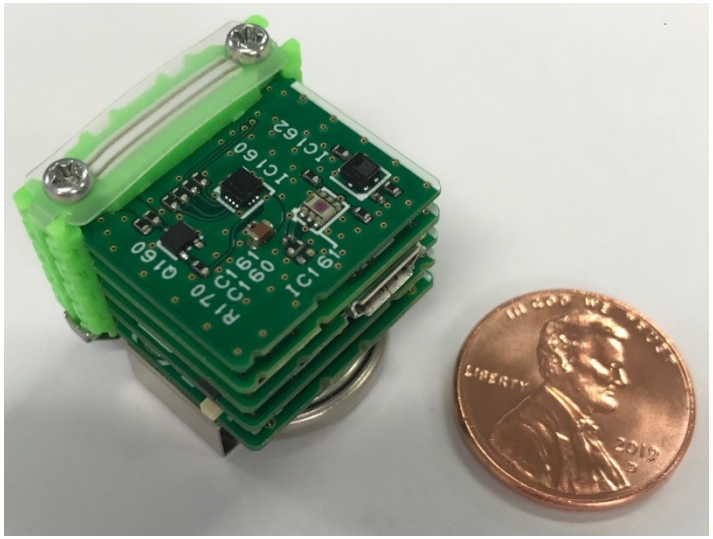
Development Issues of IoT module “Leafony”

- Issue1: Compact 3D assembled substrate design
  - 3D clearance check
  - 3D collision check
  - 3D electro connection check



- Issue2: Complete prototype quickly with low cost
  - Decreases efficiency if design and manufacturing takes a long time
  - Low volume manufacturing is costly

Challenges in both substrate design environment and prototype manufacturing

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Issue1 : 3D assembled substrate design

- 2D substrate design
  - 2D electrical connection check
  - single board DRC

2D Layout CAD

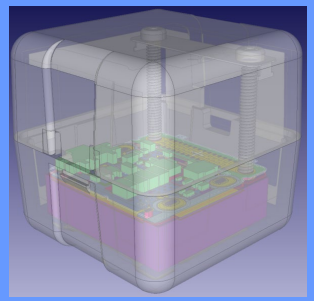
Substrate design

iteration

Need 3D layout

- Mechanical design
  - Can't check electrical connection
  - Can't check design by rule
  - Takes time to create data

Mechanical CAD



・3D collision check
・assembly check

A board design env. that considers 3D layout during design is required

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Issue2 : Complete prototype quickly with low cost

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- Steps of IoT prototyping by Leafony
  - Use existing leaf motif
  - Create necessary new leaf module
    - Design new module
    - Assemble new PCB
    - Mount new component on PCB

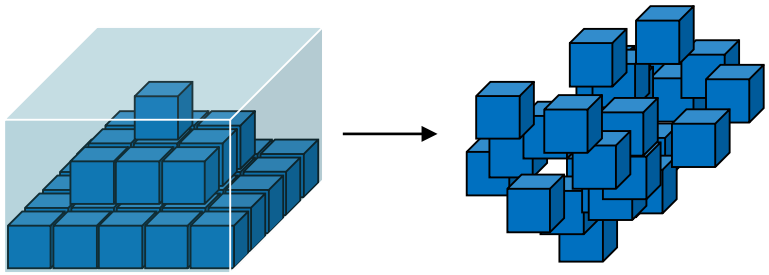
- Takes at least 1 week
- High cost for low volume

Design and manufacture of prototype with short TAT, low cost is required

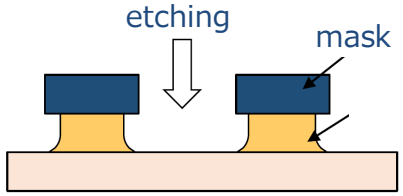
Prototyping by Additive manufacturing

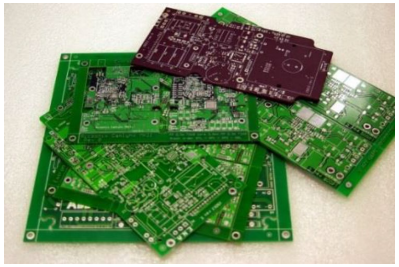
Subtractive manufacturing

➔constructed by cutting material away



Circuit formation

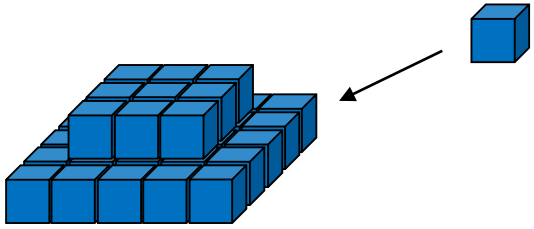




http://www.extrondesign.com.au/pcb-design.htm

Additive manufacturing

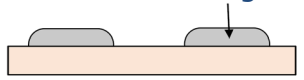
➔constructed by depositing material



Material technology
- metal nano colloidal
- conductive paste

Printing technology
- ink jet
- dispenser
- photo printing
- screen printing

Direct printing of conductive material → sintering



http://www.fujikura.co.jp/eng/rd/gihou/backnumber/pages/__icsFiles/afieldfile/2014/07/04/43e_06.pdf

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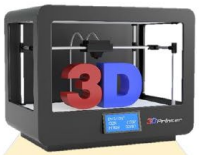
Additive manufacturing by Electronic device manufacturing printer

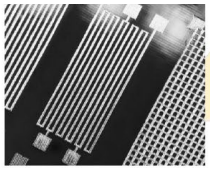
- Integration of three functions : “FPM-Trinity”



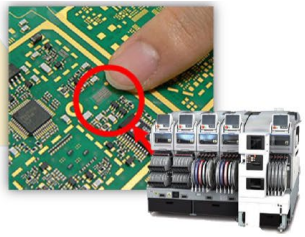
3D printer

FPM-Trinity

Electric circuit printing

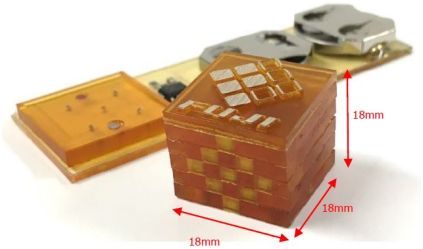


Component mounting



- Sample cases

LED cube



Glasses with gyro sensor

IoT module

Source of reference: FUJI Corporation, FPM-Trinity https://www.fuji.co.j@/about/fpm-trinity/

Electronic device manufacturing printer I/F

- Create circuit board with a 3D printer

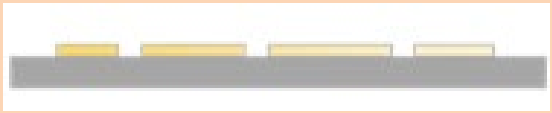
2D CAD

Module design
(Case, Circuit)

Mechanical CAD

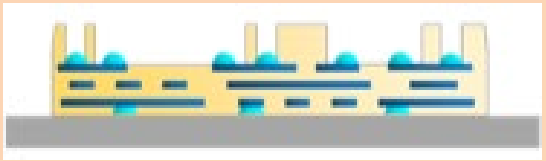
Import DXF
↓
Create Resin shape data
↓
Create Circuit shape data
↓
Create Component & bump location data
↓
Export final STL

FPM-Trinity
(Electronic device manufacturing printer)



Dielectric layer formation

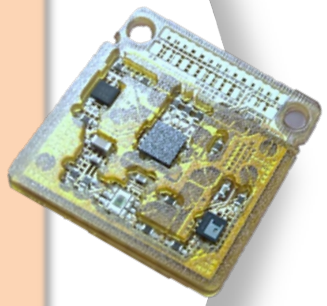
Electric circuit formation



Bump formation

Component mounting

Finish



Takes time to create data by Mechanical CAD

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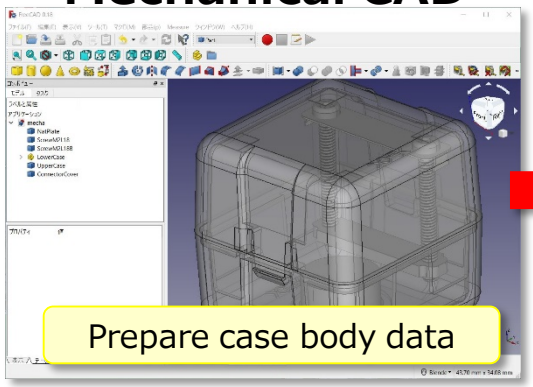
- Background and Motivation
- Technical challenges
- Motif data
- Results
- Conclusions

CR-8000 Design Force
Electronics & Mechanical Co-design

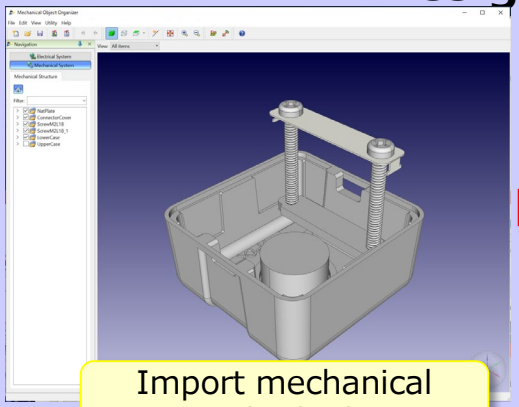
- 3D DRC and 3D collision check during substrate design

Mechanical CAD

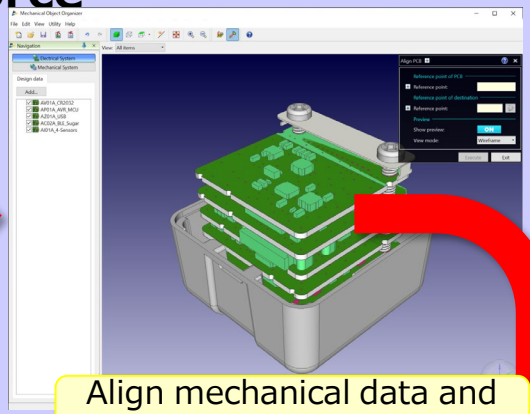


Prepare case body data

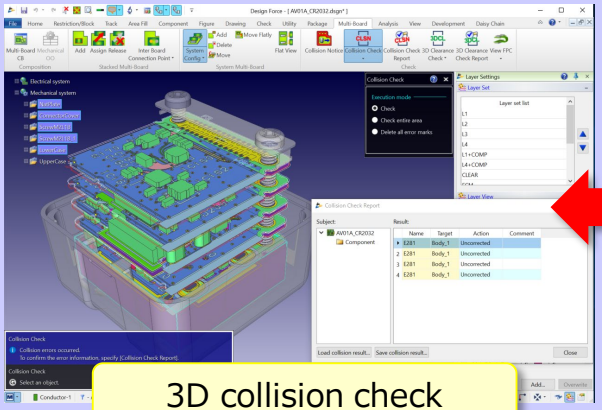
Design Force



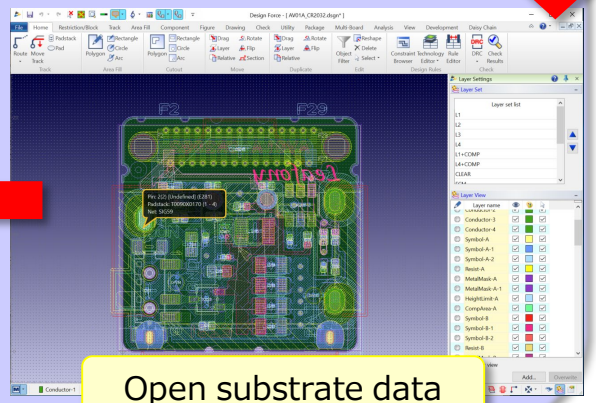
Import mechanical case body data



Align mechanical data and substrate data



3D collision check

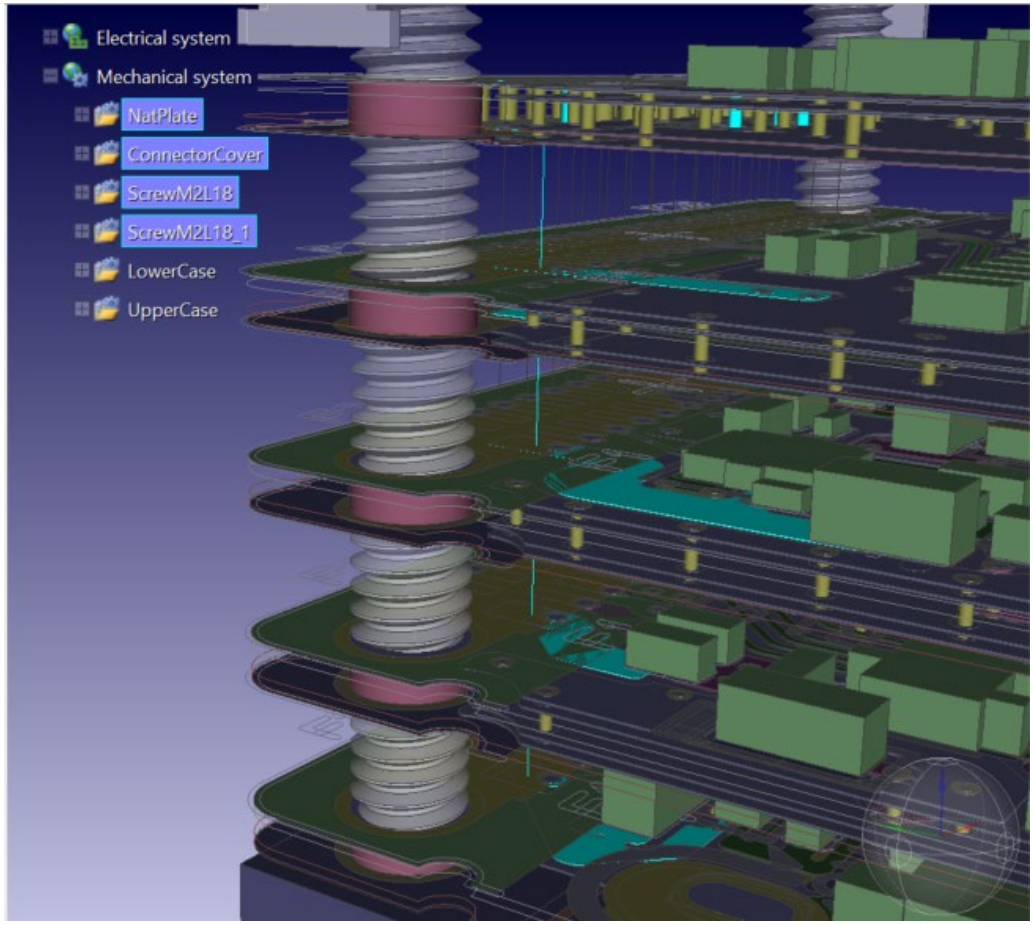


Open substrate data

Reduce iteration b/w substrate design and mechanical design

CR-8000 Design Force
3D assembled multiple board design

- System nets connection between multiple board design



Electrical connection check b/w Leaf substrates

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CR-8000 Design Force
Electronic device manufacturing printer I/F

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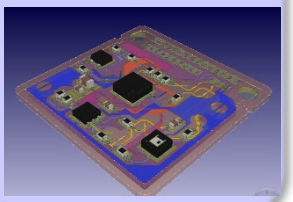
- Passing digital data from the board CAD to printer

CR-8000 Design Force

Module design
(Case, Circuit)



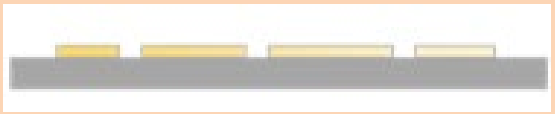
I/F digital data

- Resin shape 3D data
- Circuit shape 3D data
- Component & bumps location data

Input raw material

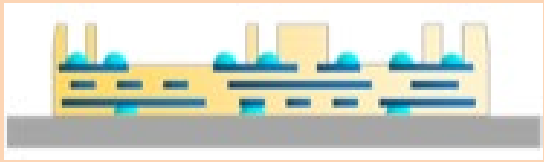
- UV resin ink
- Nano silver ink
- Ag paste
- Component

FPM-Trinity
(Electronic device manufacturing printer)



Dielectric layer formation

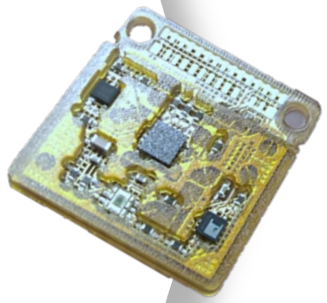
Electric circuit formation



Bump formation

Component mounting

Finish



Realize short TAT & low-cost prototyping

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- Background and Motivation
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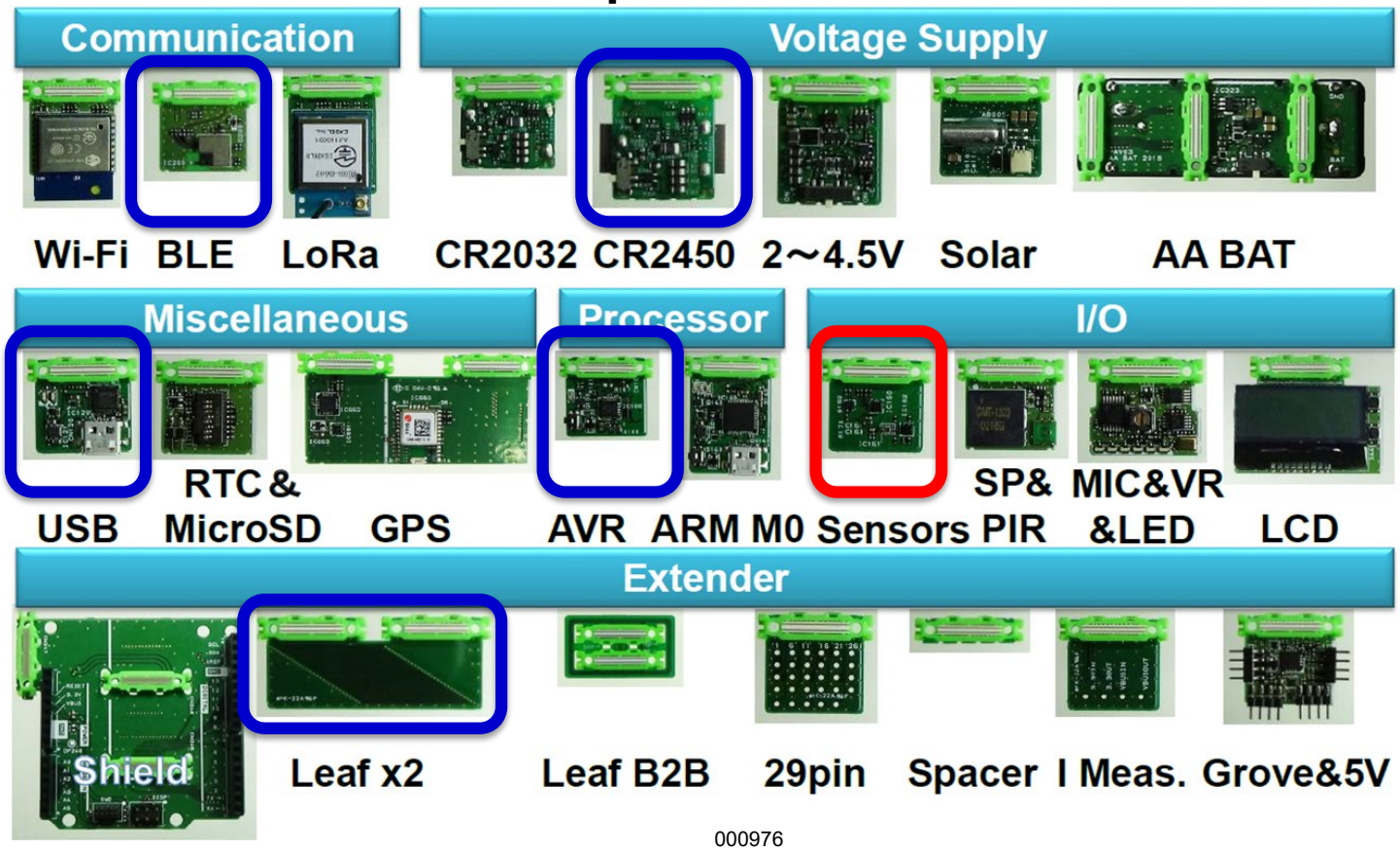
Motif data

- Apply usable leaf modules
- Design & manufacture new sensor module only

Open leaf module



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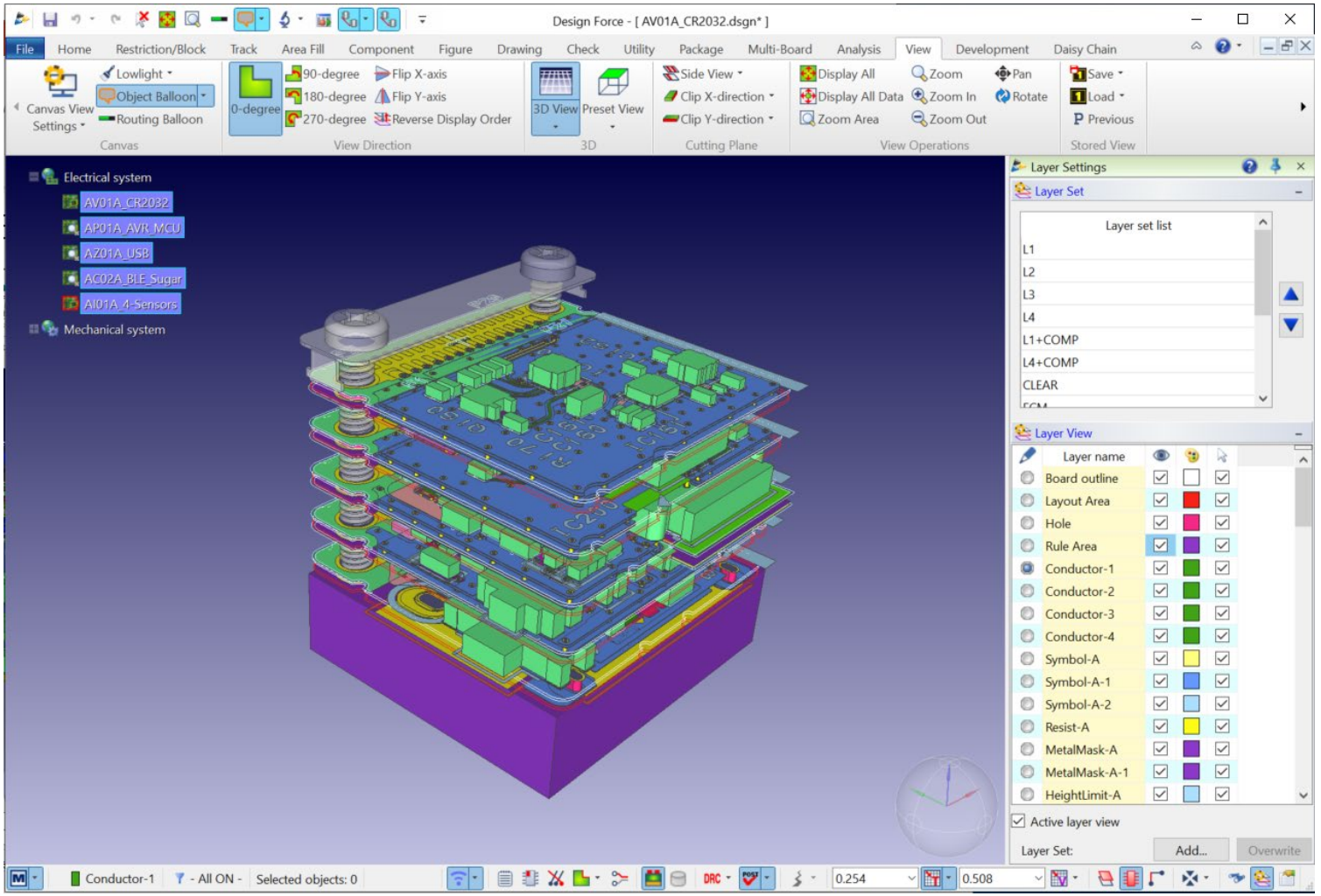
Electronics & Mechanical Co-design

- Sensor leaf design & 3D clearance check by Design Force



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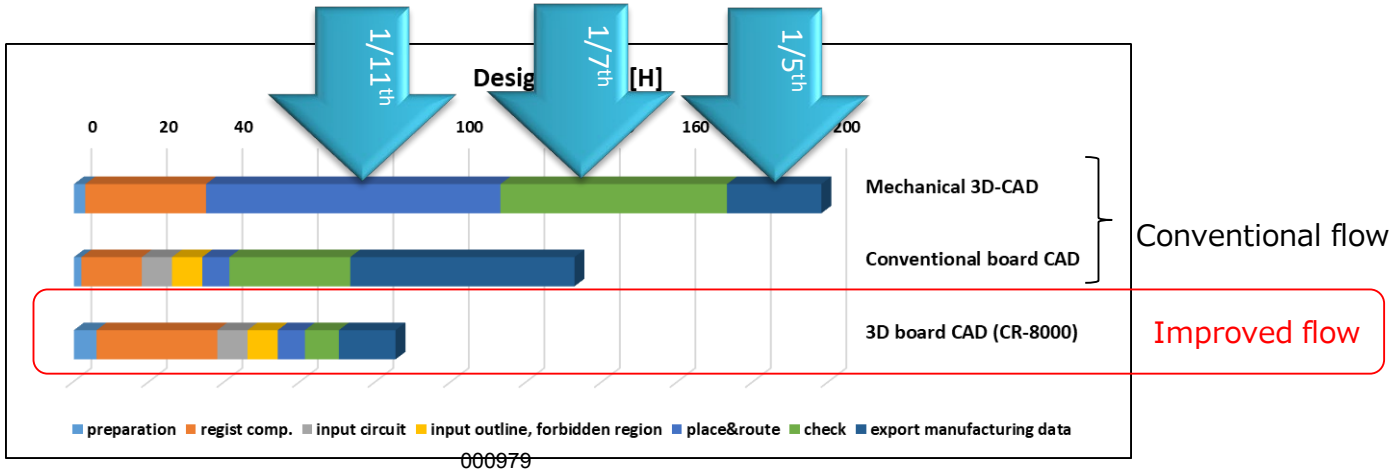
Effect of improving 3D substrate design flow

- Reduce TAT while improving quality

✓ ① Registration manufacturing data in component library
✓ ② 3D view each module associated case data
✓ ③ move components b/w modules in substrate design linked with circuit design
✓ ④ modeling the pin shape exactly for 3D stack
✓ ⑤ Leaf module imposition by substrate CAD
✓ ⑥ Change output data from STEP to STL
✓ ✓ ⑦ Apply manufacturing correction by substate CAD
✓ ⑧ Output final digital data to 3D printer from substrate CAD
✓ ⑨ Output coordinate data of mounted components
✓ ✓ ⑩ Output data for electric checker
✓ ✓ ⑪ Output manufacturing data at once by batch

✓ : improve quality

✓ : reduce man-hours



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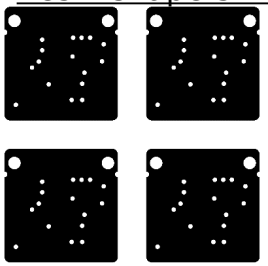
Sensor leaf prototyping & testing

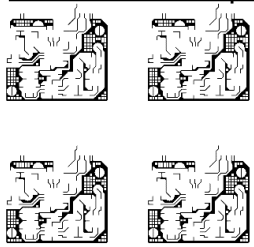
- Confirm 100% yield

Result → OK (4/4 pcs)

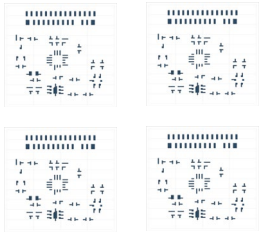
Resin shape 3D data



Circuit 3D shape data

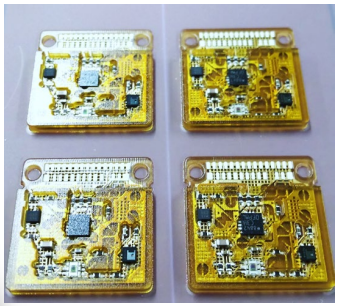


Component & bumps Location data

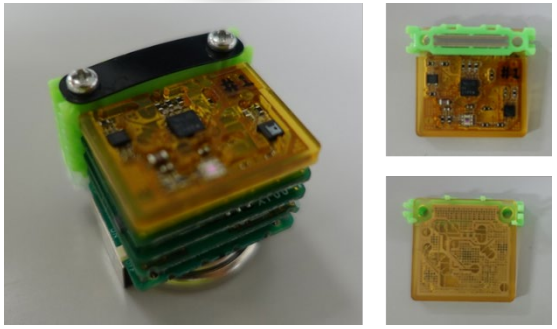


Printing

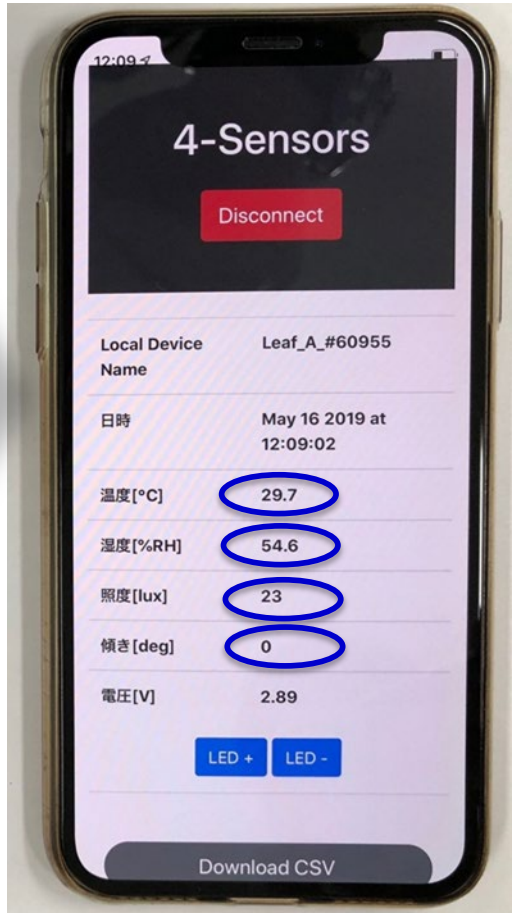
Prototype board (4pcs)



assemble



Operation test



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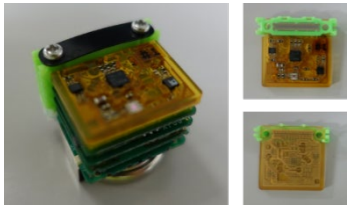
Conclusions

- IoT module design by 3D-CAD
  - 3D clearance & 3D collision check during substrate design
  - Electrical connection check b/w multiple modules
  - Seamless and straight design w/o wasteful iteration
  - Efficient data I/F directly to electronic device manufacturing printer
- Shorter development period by above design environment & the IoT module development platform
  - Complete IoT prototyping within 3 days keeping quality
  - Complete low volume prototyping with low cost using additive manufacturing



Product ideas come true on demand

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The Partner For Success

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