On-Demand Manufacturing of Electronics

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INTRODUCTION

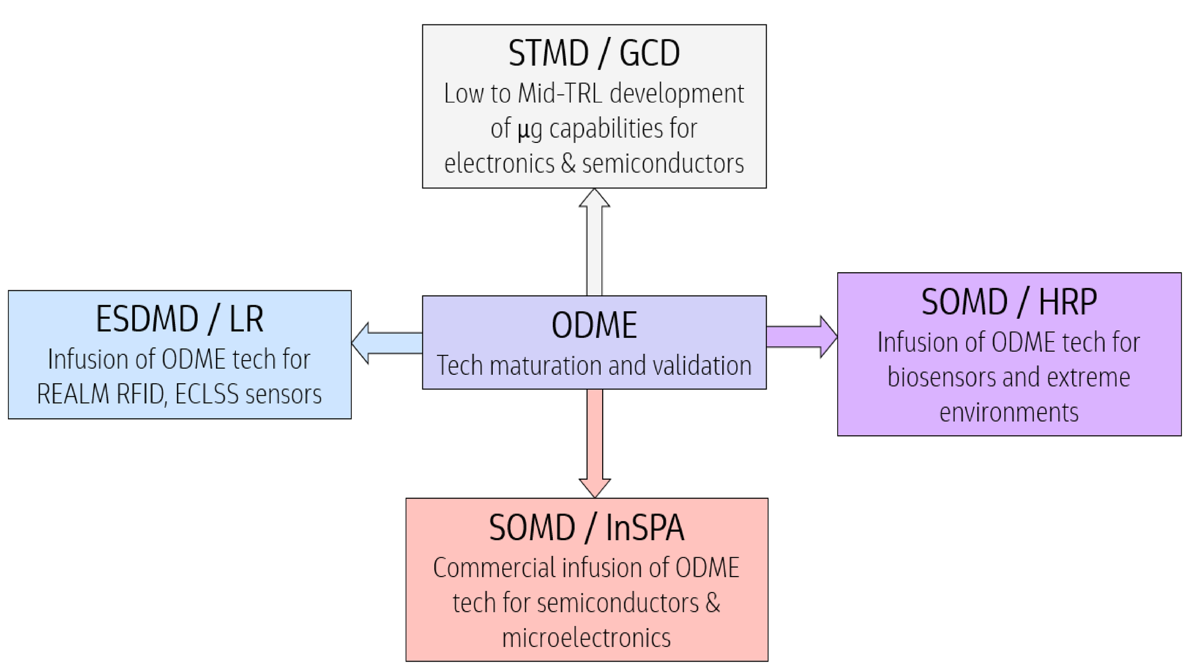
The On-Demand Manufacturing of Electronics (ODME) project supports the development of materials, processes, and device designs to enable the manufacturing of electronics in low-gravity environments.

ODME is working with collaborators on the development of an Advanced Toolplate System (ATS) equipped with several manufacturing tools used to create functional electronics in reduced gravity environments.

In-Space Manufacturing

NASA sends 7,000 pounds of spare parts to the International Space Station (ISS) annually at a cost of $10,000/pound or $70 million/year.

The ODME project is developing and demonstrating the feasibility of a reduced gravity, on-demand manufacturing system for electronics including printed circuit boards, sensors, power and energy storage devices, and semiconductor devices.

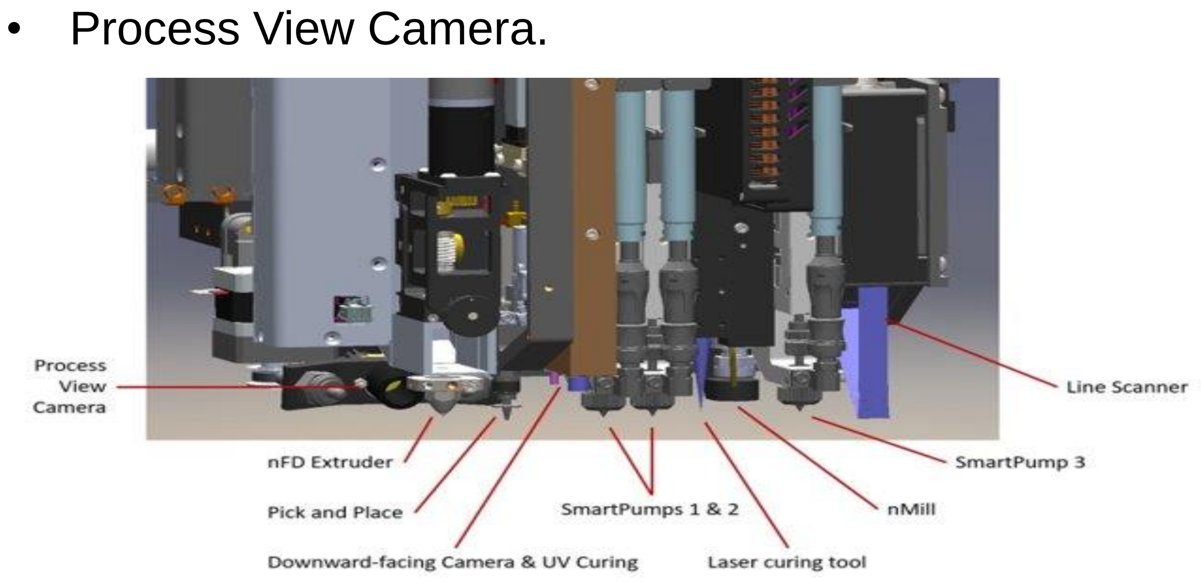


ODME role in the technical development of devices in-space for space and in-space for Earth.

Advanced Toolplate System (ATS)

The Advanced Toolplate System (ATS) provides a complete manufacturing suite for flexible hybrid electronics (FHEs). ATS is equipped with:

- Smartpump for extrusion printing
- nFD extruder for filament deposition
- Pick and place tool for component placement
- nMill for precision milling, drilling, and polishing
- Laser and UV curing tools
- Process View Camera.



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Advanced Toolplate System with 8 integrated tools providing a variety of process capabilities within the same volume.

Technology Development Path

ODME supports the development of the inks/materials, new printing systems, and electronic designs that are first tested experimentally in 1g.

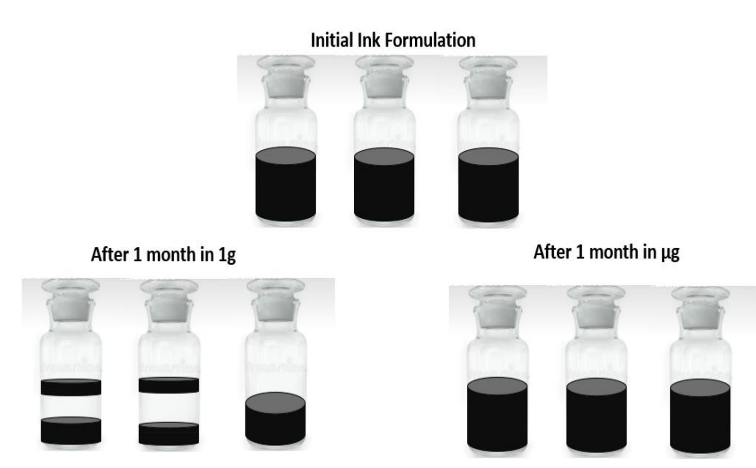
Parabolic flight demonstrations allow zero gravity validation and assessment of high priority technologies for in-space manufacturing.

The toolheads being developed for the ATS are miniaturized by 35% compared with the commercial nScrypt tools.

In partnership with Flight Opportunities experiments on the ATS have been carried out on several tools validating them in 0g.

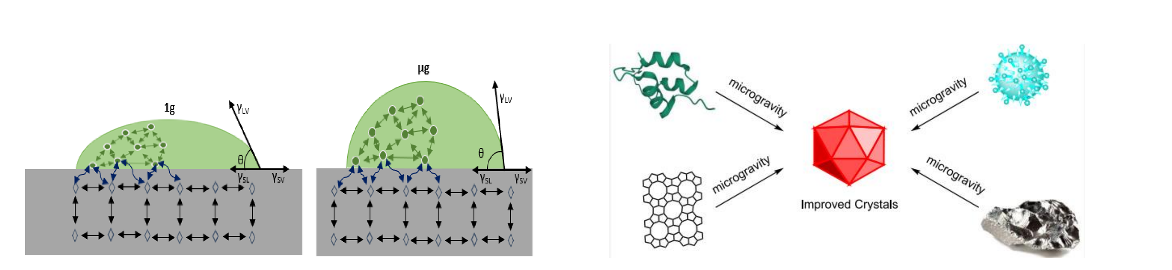
Materials – Related µg Impacts

Sample preparation stage (before printing)



- µg removes convection, sedimentation, and buoyancy that can disrupt physical and chemical processes.
- Less aggregation and sedimentation of colloidal active materials → higher stability and longer ink shelf life.

Manufacturing stage (during printing/fab)



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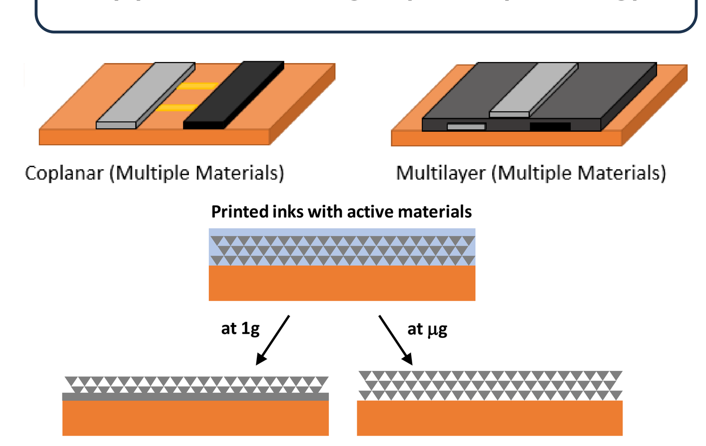
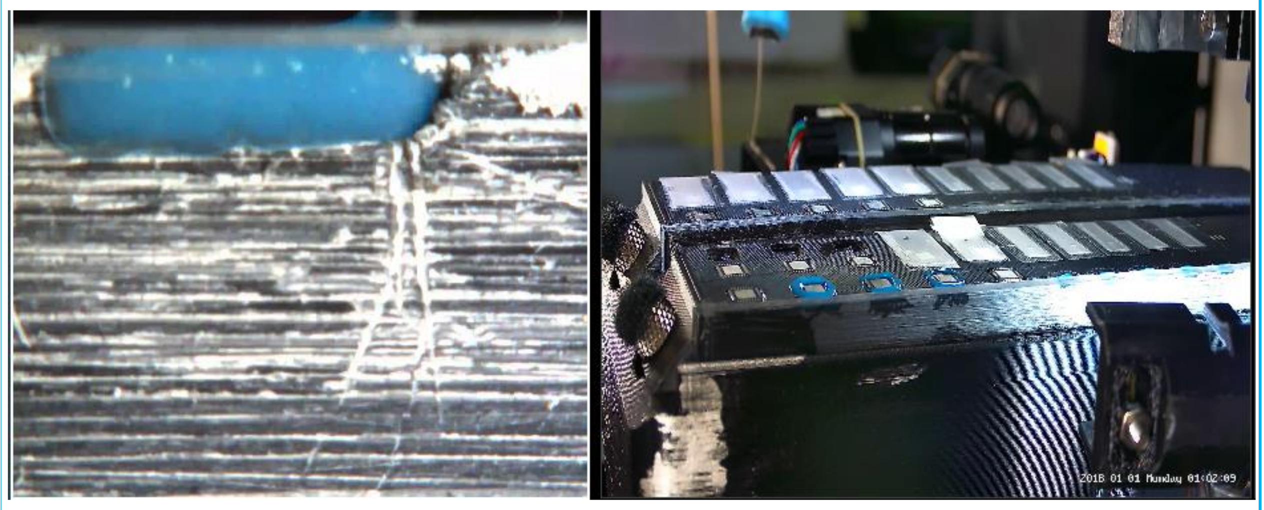
- Diffusion and surface tension-dominant processes enables more uniform structures at individual molecule level.
- µg allows bigger crystal sizes and fewer defects during crystal growth → high quality.

Application stage (after printing)



- In printing, a higher concentration of the active material in inks allows superior performance and reliability.
- Multilayer fabrication is enabled to form integrated systems with multiple functional devices with a high degree of complexity.

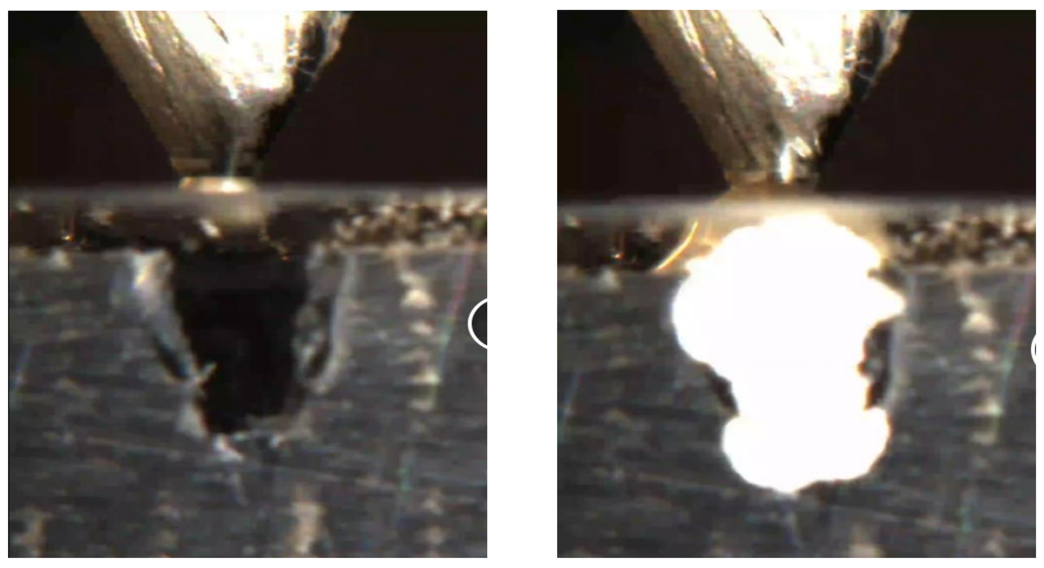
Parabolic Flight : Chip Integration



Parabolic flight via-filling experiment with UV-curable dielectric.

Moat filling enables an insulating material to be deposited to separate conductive traces. It also facilitates components to be secured within the cavity allowing complex circuits to be produced on the Advanced Toolplate System.

Parabolic Flight: Via-Filling



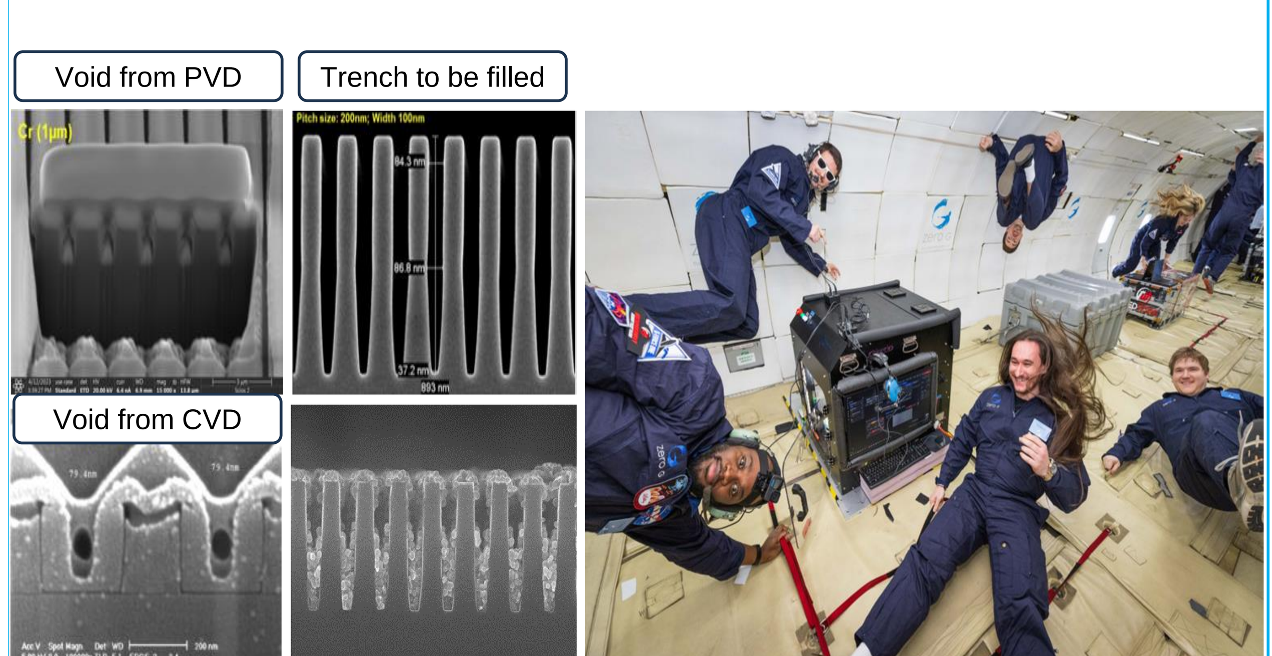
Parabolic flight via-filling experiment with conductive silver ink.

Vertical Interconnect Access (Via) are small holes used to connect different layers of a circuit. Via-filling is a pivotal part of creating intricate electronic devices with increased performance.

Enabling Semiconductor Manufacturing in Space

NASA's InSPA (In-Space Production Applications) is investing to propel the U.S. into being the world's leaders for in-space manufacturing of semiconductors.

- 3D printing of semiconductors in microgravity reduces defects and manufacturing costs.
- ODME parabolic flights scheduled in August 2024 will test the electrohydrodynamic (EHD) inkjet tool in the ATS. In µg this tool can enable high-density, high-performance memory fabrication.



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Images 1-4: Advantages of µg trench filling with EHD over traditional vapor diffusion processes used in semiconductor manufacturing.
Image 5: ODME parabolic flight team during February 2024 campaign.