- In-Space Economy
  - Human Spaceflight
  - Cargo Transportation
  - Surface Spacecraft
  - Space Stations
  - Surface Habitats
  - In-Space Manufacturing
  - Space Resources
  - Space Utilities
  - In-Space Transportation
  - Miscellaneous
  - Ecosystem Map
  - Graphs & Taxonomy
- Database (Previous)
  - Manufacturing Companies
  - Microgravity Services
  - Space Resources Services
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  - Graphs & Taxonomy
- Microgravity
  - Zeolites
  - ZBLAN and Exotic Fibers
  - Whisky
  - Ultra-Thin Coatings
  - Superconductors
  - Superconducting Supercomp
  - Space Farming
  - Space Arks
  - Silicon Carbide
  - Quantum Computers
  - Perfect Spheres
  - Organic Tissue
  - Orbital Microfabrication
  - Medicine and Drugs
  - Large Space Structures
  - Fragrance
  - Diamond
  - Coffee
  - Chocolate
  - Carbon Nanotubes
  - Bulk Metallic Glass
  - Beer

Orbital Microfabrication

Database > Microgravity Applications > Orbital Microfabrication

Fabricating microchips or semiconductor crystals in orbit by benefitting from ultra-high vacuum among others. Microgravity-grown crystals have increased single crystal size and suppressed impurities and defects.[4]

Field: Products | Destination: Earth | Trend: Coming for sure | Timeline: Long-term

Last updated: 2020-09-05

Status

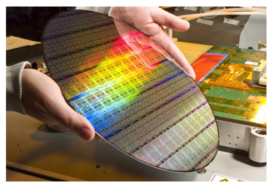
Terrestrial microfabrication techniques are difficult to transfer into microgravity and other methods have been developed and tested on a small scale in space. Microgravity Research Associates was founded in 1979 to produce gallium arsenide chips, but has been dormant for decades. Made in Space was selected by NASA in 2020 to develop autonomous semiconductor chip manufacturing.

TRL: 4

Applications

- Gallium Nitride (GaN)
- Gallium Nitride on diamond (GaN-on-diamond)
- Gallium Arsenide (GaAs)
- Silicon Carbide (SiC)
- Space-based microsensors

Why & Solution



Link

Semiconductor microchips are high value per mass products whose fabrication requires many of the resources available in low-Earth orbit. It is hypothesized that orbital fabrication of silicon microchip devices may be more economically attractive than traditional Earth-based fabrication based upon the inherent advantages of the space environment: vacuum, cleanliness, and microgravity.[3]

Gallium nitride, used to make LEDs, is difficult to solidify in large amounts at a time because its two constituent molecules don't always bind perfectly in order, leading to defects. Reducing the movement of the melted fluid as hotter and less-dense fluid rises, which occurs because of gravity, can decrease those defects — as can preventing the highly reactive substance from touching the sides of its container, according to Randy Giles, chief scientist at the Center for the Advancement of Science in Space. Someday, substances like that could benefit from in-space creation.[2]

Using orbital vacuum for enhanced semiconductor fabrication was pioneered in the Wake Shield project which produced ultra-high vacuums for epitaxial growth of high quality GaAs like materials. A proposed alternative uses the native Low Earth Orbit vacuum levels to achieve the silicon microfabrication processes needed for manufacturing silicon microchips. However standard terrestrial fabrication techniques are difficult to transfer into the microgravity and vacuum environment of space. They are optimized for using in-situ resources: water, power, air pressure and gravity that are plentiful on Earth. An alternative microfabrication process has been developed using the native vacuum environment which could replace wet terrestrial based microfabrication, with significant savings in equipment size, mass and consumables, while reducing cycle time.[3]

It is found that by developing new, dry processes that are vacuum compatible, fabricating semiconductor devices in orbit is both technically and economically feasible. The outcome is a synergistic, orbital-based methodology for micro-fabrication capable of building and delivering commercially marketable microfabricated structures. The base case modeled, production of 5,000 ASIC wafers per month, indicates that orbital fabrication is 103% more expensive than existing commercial facilities. However, optimization of process parameters and consumable requirements is shown to decrease the cost of orbital fabrication dramatically. Modeling indicates that the cost of orbital fabrication can be decreased to 58% that of an advanced, future Earth-based facility when trends of increasing process equipment costs and decreasing orbital transport costs are considered.[3]

Taking advantages of microgravity environment, amorphous semiconductors made a remarkable improvement both in quality and quantity. Space is considered to be a favorable environment for many things including the followings that were investigated: semiconductor joining by atomic adhesion, fabrication of thin films of diamond and amorphous silicon alloys, CVD processes, production of super-minute grains, light element analysis by SIMS (Secondary Ion Mass Spectrometry), and anti-proton generation by laser accelerators. This report reviews the potentials of material processing in space. Processing technologies of spacecraft construction materials, thin solid films, and fine alloys are reviewed. Light element analyzing method and antiproton storing technology for liquid metal MHD (Magnetohydrodynamic) power generator are also reviewed.[5]

Made in Space was selected to develop an autonomous, high throughput manufacturing capability for production of high quality, lower cost semiconductor chips at a rapid rate. Terrestrial semiconductor chip production suffers from the impacts of convection and sedimentation in the manufacturing process. Fabricating in microgravity is expected to reduce the number of gravity-induced defects, resulting in more usable chips per wafer. Market applications include semiconductor supply chains for telecommunications and energy industries.

Companies

G-Space

G-SPACE Inc is a one-stop shop platform to design microgravity products for orbital microfabrication. The company offers services such as microgravity product design, optimization of the microgravity manufacturing process, and insights into customized market data for in-space manufacturing. If you are not sure where to start with microgravity and in-space manufacturing, the company will provide the most optimum starting point for microgravity fabrication at savings of 10X.

Design and test your materials, manufacturing processes and experiments before leaving the atmosphere using our AI-powered SaaS platform, ATOM™.

G-Space aims at developing the ability to identify, define, and optimize the precise operational spectrum for space manufacturing to ensure manufactured products are at their highest quality and performance.

G-Space's long-term vision is to move polluting manufacturing off the surface of the Earth into its orbits.

G-Space, Inc. brings exclusively to the US market a suite of Heavy Metal Fluoride (ZBLAN, InF3, etc.) from our French partner Le Verre Fluoré.

MERCURIA™ is a market optimization engine uniquely constructed to provide estimates of addressable market sizes for in-space manufactured products **with terrestrial demand**. The software tracks product superiority, manufacturing process scalability and standardization, and sustainability opportunities (greenhouse gas emission, etc) along realistically constructed commercialization timelines for in-space manufactured products.

ATOM

NASA SBIR award in 2020 for Advanced Terrestrial to Orbital Manufacturing (ATOM) platform that builds on a terrestrial experimental technique, Gravity Elimination via Methods of Suspension (GEMS), enhanced through the addition of first-principles modeling, computational tools, and machine learning algorithms.

- G-Space is the only commercial company that provides a tool in advanced material manufacturing that harnesses the effect of gravity on material stability and narrows down the optimized 0G manufacturing envelope.
- The main objective of this SBIR Phase I is to develop a conceptual design of GEMS and to complete the buildout and beta testing of the ATOM platform, including a data manager, analysis and reporting system.
- The resulting platform will be validated using primarily in-house Heavy Metal Fluoride Glass data. In addition, the platform will be expanded to ingest selected material data from NASA's Microgravity Database as well as an additional suite of high profit margin materials with potential for fabrication in a zero G environment.

Demo video for ATOM AI-powered SaaS Platform for accelerating in-space manufacturing by designing with gravity here on Earth.

NASA's Physical Sciences Research Program has selected five ground-based proposals in response to the Physical Sciences Informatics System call for proposals. This program element is part of Science Mission Directorate (SMD) Research Opportunities in Space and Earth Sciences - 2021 (ROSES-2021) solicitation. These five research projects, involving recognized experts in the fields of combustion science, complex fluids, fluid physics, informatics, and materials science, will use data contained in the PSI system and build on prior reduced-gravity research to advance fundamental research in the physical sciences.

- *"Development of a computer vision based toolbox for feature extraction, analysis, modeling and prediction of microgravity data sets"*

ZBLAN IN-SPACE FIBER OPTICS MANUFACTURING

Raw Materials
A new product: ZBLAN (fluorozirconate) preforms for space manufacturing!
ZBLAN standard rods (⌀12.5mm, L=120mm) represent an exclusive new product, specifically designed for In-Space Manufacturing. Contact us for custom requirements.

Thermal Modeling For Fiber Drawing Automation
ATOM™ thermal modeling helps maintain optimal conditions for the fiber optics processing and manufacturing (including gravity correction)

In-Space Monitoring of Fiber Drawing Process
ATOM™ analytics and customized computer vision algorithms ensure that the optimal regime for microgravity processing is maintained. They also offer the ability to monitor and correct promptly key fiber optics parameters (fiber diameter uniformity, concentricity, etc.) during the in-space manufacturing process.
Quality Control and Validation (pre and post flight)
Provide best terrestrial manufacturing reference; inspection of a suite of fiber properties (attenuation, defects, etc.) and estimates of contributions (including gravity correction) that lead to loss of performance.

Faraday Technologies

Faraday Technology will create an in-space manufacturing process to directly print next-generation covetic materials (nanocarbon-infused metals/alloys) in Low Earth Orbit (LEO) via an electro-co-deposition approach to leverage the unique capabilities of the International Space Station (ISS).

LEO Manufacturing of 3D Printed Covetic Nanomaterials for Advanced Electronics

This program will develop an in-space material manufacturing approach to leverage the unique capabilities of the International Space Station.

Specifically, one such, exemplar novel class of material, covetics (nano-carbon-infused metals), are inherently challenging to produce terrestrially but have great commercial potential due to their enhanced physicochemical properties as compared to conventional metals, such as high thermal (50% higher than Cu), high electrical conductivity (40% higher than 6061 Al), and high strength (30% higher yield strength than Cu).

Therefore, Faraday Technology and the University of Texas in Dallas will develop a material manufacturing process to directly print these next generation covetic materials in Low Earth Orbit (LEO) via an electro-codeposition approach.

This work will build on the University of Texas's direct Cu printing platform which has been demonstrated at pre-commercial scale the potential to print large area circuit board lines utilizing a localized pulse electrodeposited (L-PED) technique.

Additionally, this work will build on Faraday's electro-code position process activities that include depositing carbon materials into copper. In Phase I we will establish the viability of directly printing covetic materials by developing the direct write hardware and the electro-codeposition electrolytes to deposit electrochemically reduced carbon materials into a copper matrix in an orientation opposite or perpendicular to gravity such that we can demonstrate at the lab scale, the potential to form covetic materials with enhanced electrical, thermal, and mechanical properties.

This demonstration would enable a preliminary market need assessment (Phase I) and zero gravity flight demonstration (Phase II), which could establish a commercial market for in-space manufacturing of these exciting covetic materials. If successful the results of the Phase I/II program will set the stage for LEO commercialization of this manufacturing process.

Nebula Interplanetary Systems

We manufacture transistors in space. The atomic-scale building block of all modern technology and infrastructure.

Redwire (Made in Space)

REDWIRE

Redwire Space is accelerating humanity's expansion into space by delivering reliable, economical, and sustainable infrastructure for future generations.

Orbital Microfabrication

Working on manufacturing electronics and semiconductors in LEO. Experiment is scheduled to fly to ISS on CRS-28 in 2023.

Developing an autonomous, high throughput manufacturing capability for production of high quality, lower cost semiconductor chips at a rapid rate. Terrestrial semiconductor chip production suffers from the impacts of convection and sedimentation in the manufacturing process. Fabricating in microgravity is expected to reduce the number of gravity-induced defects, resulting in more usable chips per wafer. Market applications include semiconductor supply chains for telecommunications and energy industries.

Microgravity Research Associates

Formed in 1979 for the purpose of engaging in materials processing in space.

Plans to grow crystals in space, starting with gallium arsenide. The high-quality gallium arsenide crystals could, in principle, be used to make chips that would be much faster than the silicon chips used in most applications. Gallium arsenide can be made on Earth, but the crystal are imperfect and the circuits are not as fast as they could be.

Earthly Solution Risk

Exists as lots of research is happening to keep up with Moore's law.

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