Cosmo Cassette: A Microfluidic Microgravity Microbial System For Synthetic Biology Unit Tests and Satellite Missions

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Introduction

Problem

- Need low-mass, controllable, repeatable platform for space based Microbial Fuel Cell(MFC) experiments on small satellite and International Space Station.
- Need standard hardware and assay for unit testing forward MFC.

Proposed Solution

- A microfluidic MFC device for small satellite and space station applications.
- Bioelectrosynthesis technology for In-Situ Resource Utilization(ISRU) and the production of food, fuel and biomaterials in space.
- Double the sample size, cost efficiency, and speed of iteration.
- A demonstration of this platform via a unit test for synthetic biology.

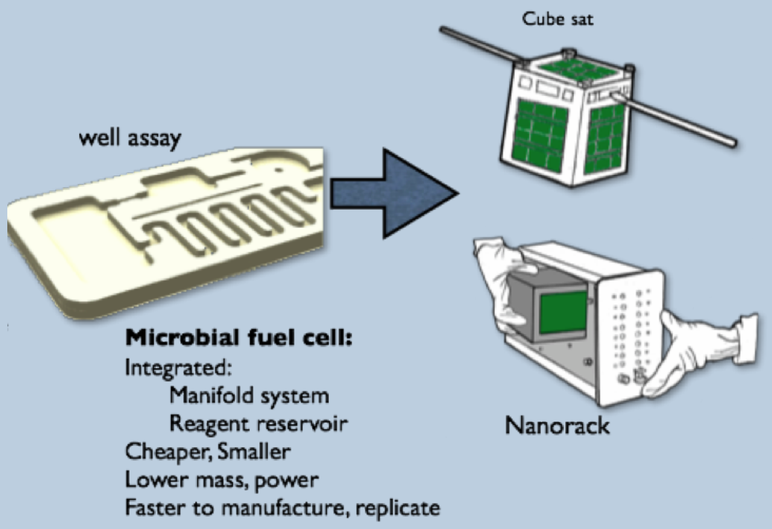
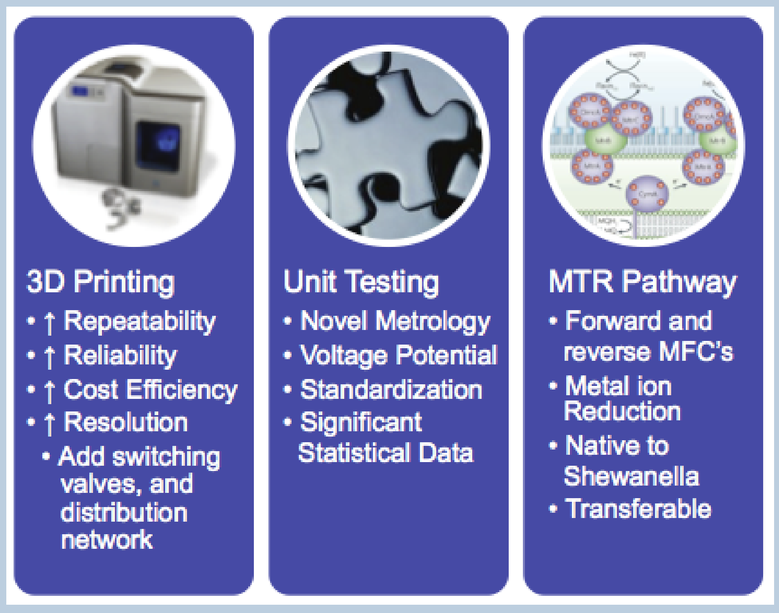


Figure 1: Proposed System and packaging for Experimental MFC biology in space.

Importance The standardized platform for synthetic biology unit tests on Earth and in space will provide metrology and growth for life support, air and water purification, ISRU, and the production of food, fuel and biomaterials. The potential space related customers of the proposed MFC are DLR: EuCROPIS, NASA small satellite program, NASA Fundamental Space Biology, NASA Synthetic Biology, NASA Life support program, Bigelow Aerospace, SpaceX, and Universal Biomining,

Technology Combination



Science of MTR Pathway

The MTR pathway is a metabolic pathway from the microbe *Shewanella oneidensis* which reduces the iron ions for the production of electricity[2][3]. Electrogenesis will be useful in space where the traditional methods of electricity generation must be modified to accommodate limited feedstock. In this case, a metal reduction pathway, native to *S. oneidensis*, will be transformed into *E. coli* and yeast through synthetic biology techniques.

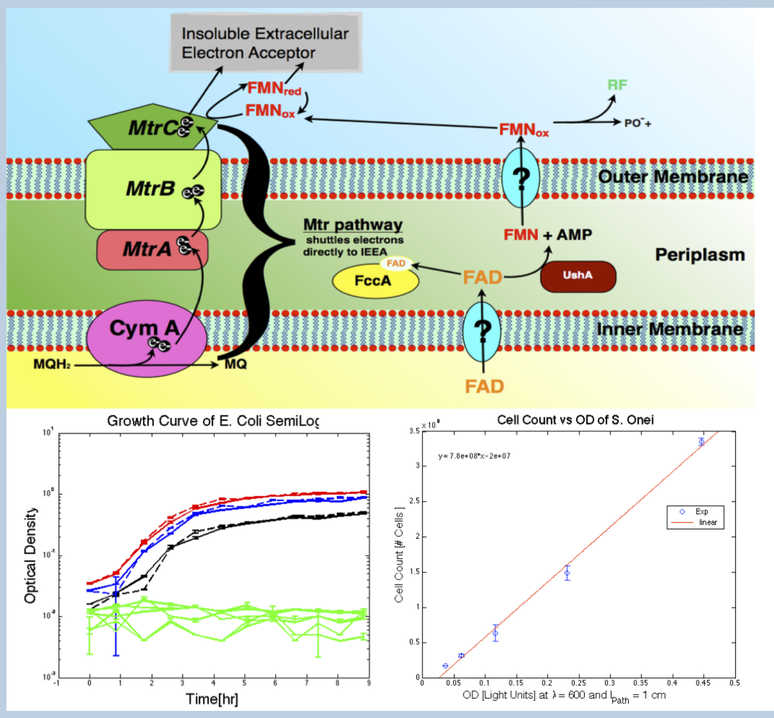


Figure 2: Top: Illustrates membrane activity of MTR pathway. Left: Growth Curves of *S. oneidensis*. Right: OD Correlated to Cell Count.

3D Printing

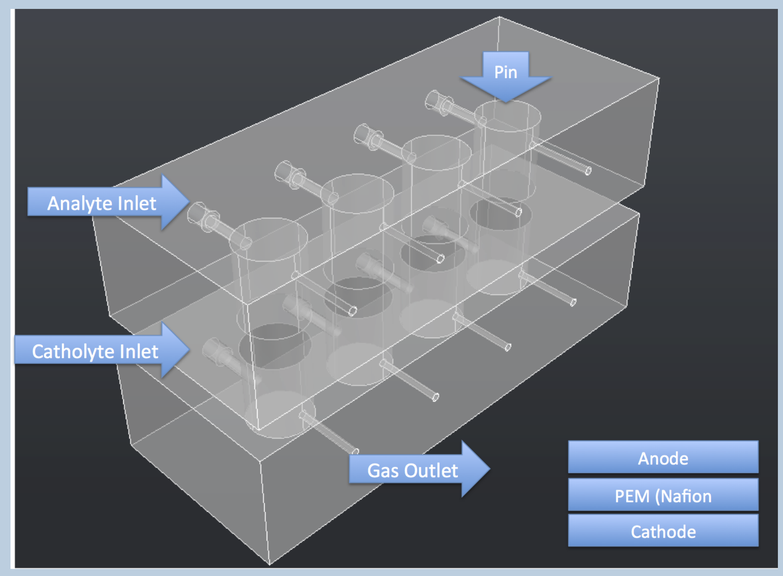


Figure 3: AutoCAD Diagram of MFC. Parts List: tubing, valves, anode chassis, cathode chassis, PEM membrane, and electrode pins, and carbon felt electrodes.

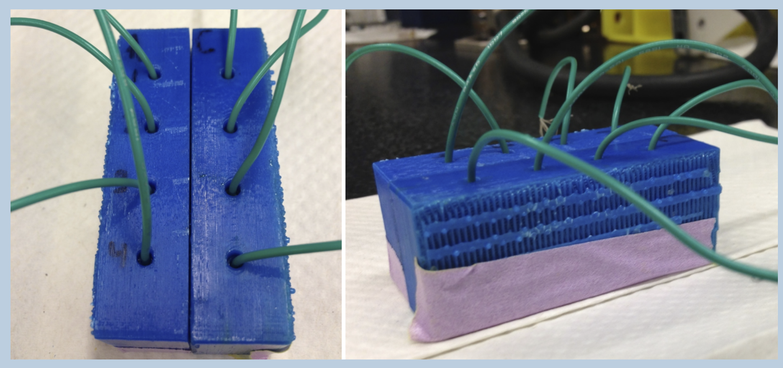


Figure 4: Photo of 3D Printed Reactor.Valves, tubing, and electrode pin design not shown. Wires connect to carbon felt electrodes within wells.

Voltage and Current Outputs

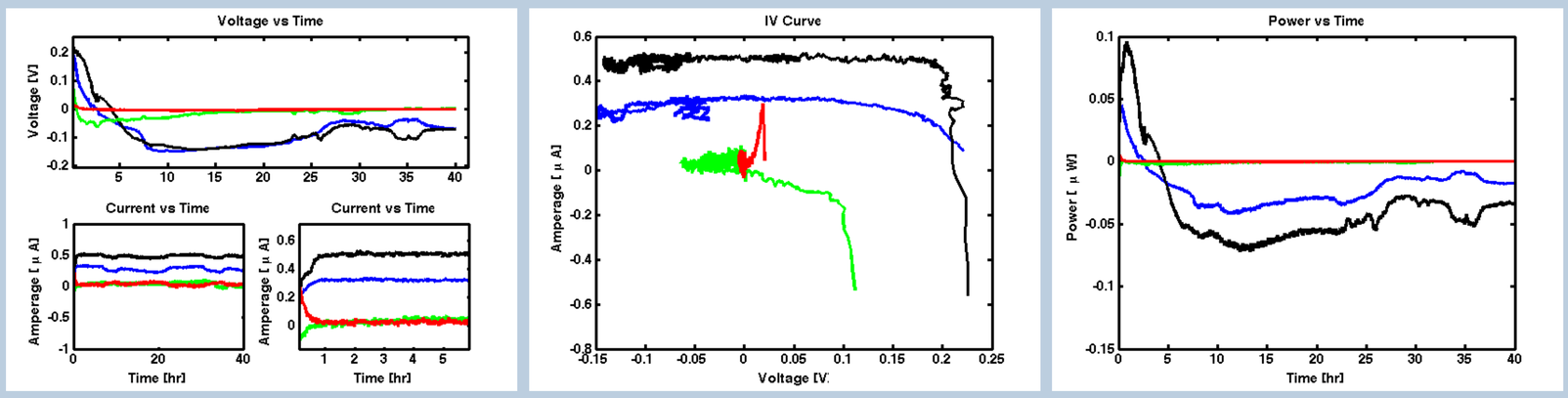


Figure 5: Left: Current and Voltage vs Time. Middle: Current vs Voltage; Right: Power vs Time. blue, black, and green are identical experimental wells, red is control.

Well	Contents	Color	Mean Current [μA]	Std Current [μA]
1	S.Onei + LB	Blue	0.274	0.033
2	S.Onei + LB	Black	0.481	.039
3	S.Onei + LB	Green	0.040	.031
4	LB	Red	0.036	.026

Table 1: Voltage, Current, and Power Outputs of printed MFC. Experimental wells contained approx. 0.4 mL of [16 mL 50mM PBS, 4 grams glucose and 6mL S. oneidensis in LB media]. Control contained 0.4 mL of 0.4 mL of [16 mL 50mM PBS, 4 grams glucose and 6mL LB media].

Electrode SEM

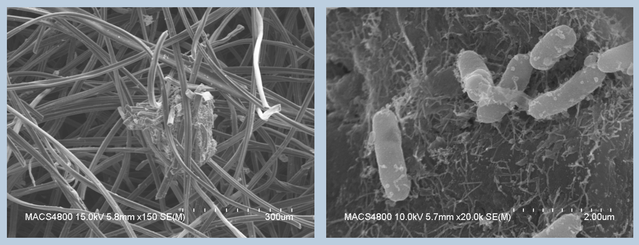


Figure 6: Scanning Electron Microscopy of anode well 1. Note *Shewanella oneidensis* adherence to carbon felt electrode. Mechanism for attachment: bionanowires.

Acknowledgements

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References

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