



# Warm Isostatic Press for Additively Manufactured ABS Outgassing Reduction in CubeSats

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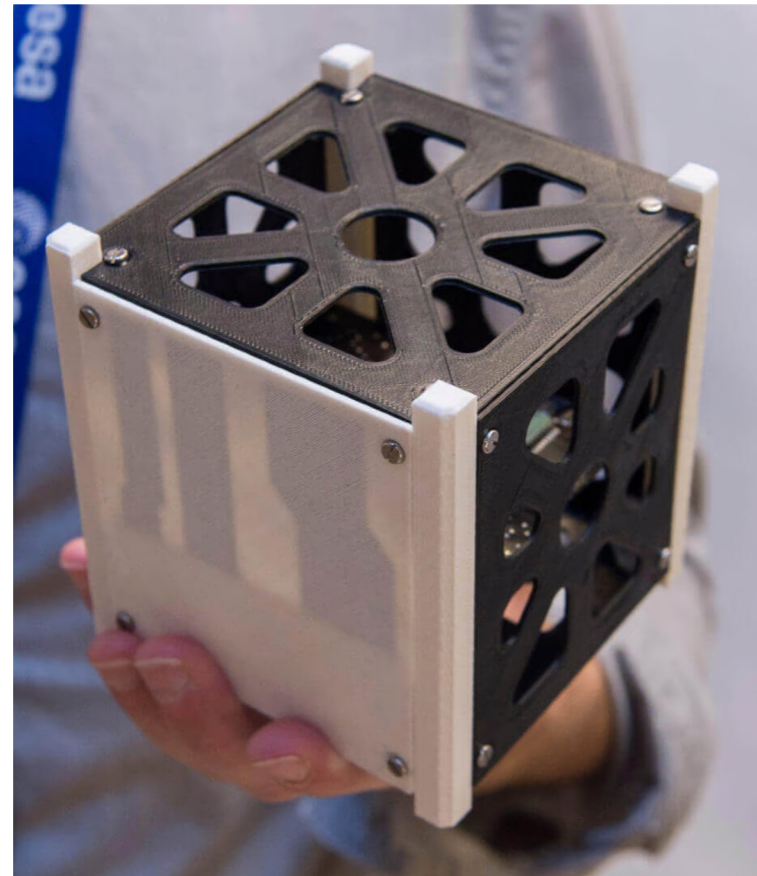
CubeSat Developers Workshop



# Motivation



- CubeSats were originally produced for educational purposes but are increasingly popular in real world applications
- Additive manufacturing (AM)
  - is common on CubeSats
  - Replicability
  - Production time
  - Cost effective
  - Lightweight
  - Complex geometries



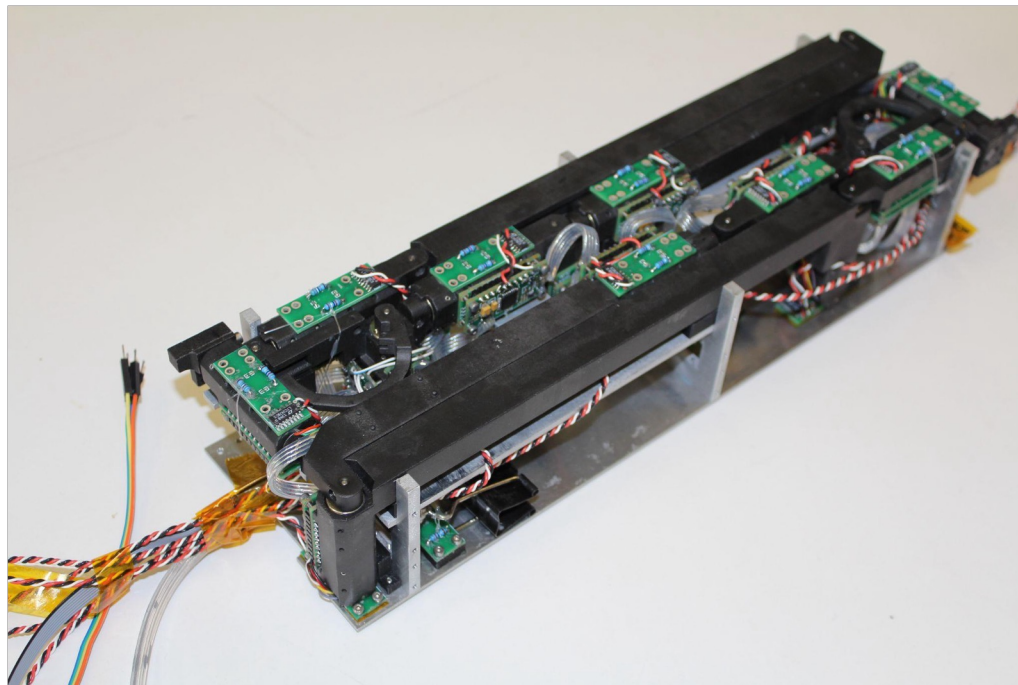
credit: <https://all3dp.com/esa-cubesat-peek/>



# Additive Manufacturing Types



- Selective Laser Sintering (SLS)
  - High quality parts
  - Expensive equipment
  - Windform XT 2.0
- Fused Deposition Modeling (FDM)
  - Inexpensive equipment
  - Imperfections in produced parts
  - Many filament materials

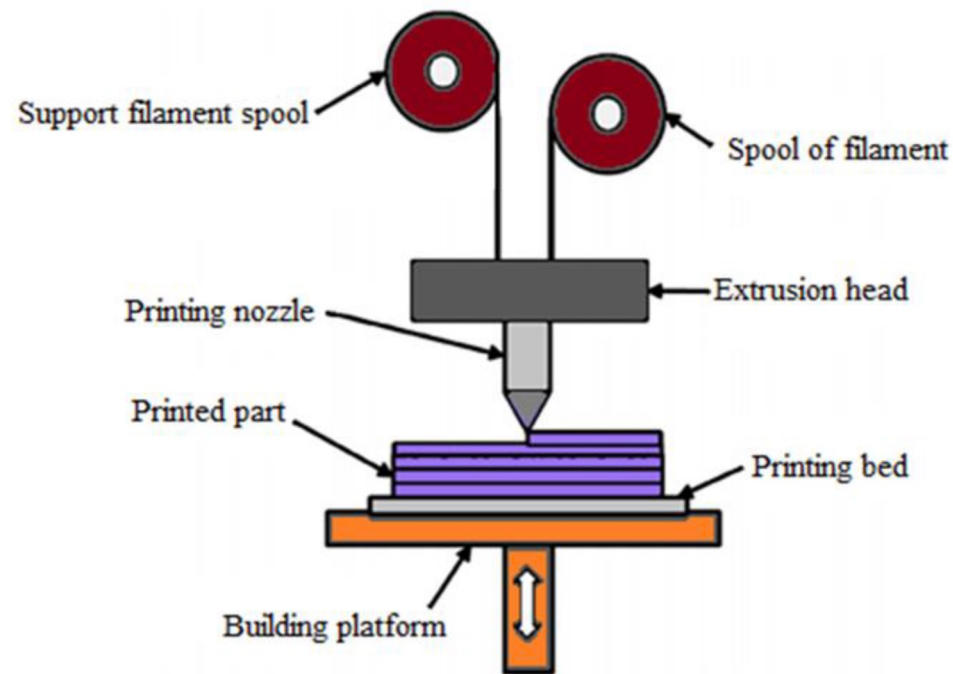


USNA RSAT uses Windform XT for Robotic Arms.



# Fused Deposition Modeling

- Structural properties inferior to traditionally manufactured equivalents
- Acrylonitrile Butadiene Styrene (ABS) is popular due to low cost of material and equipment
- FDM + ABS: outgassing

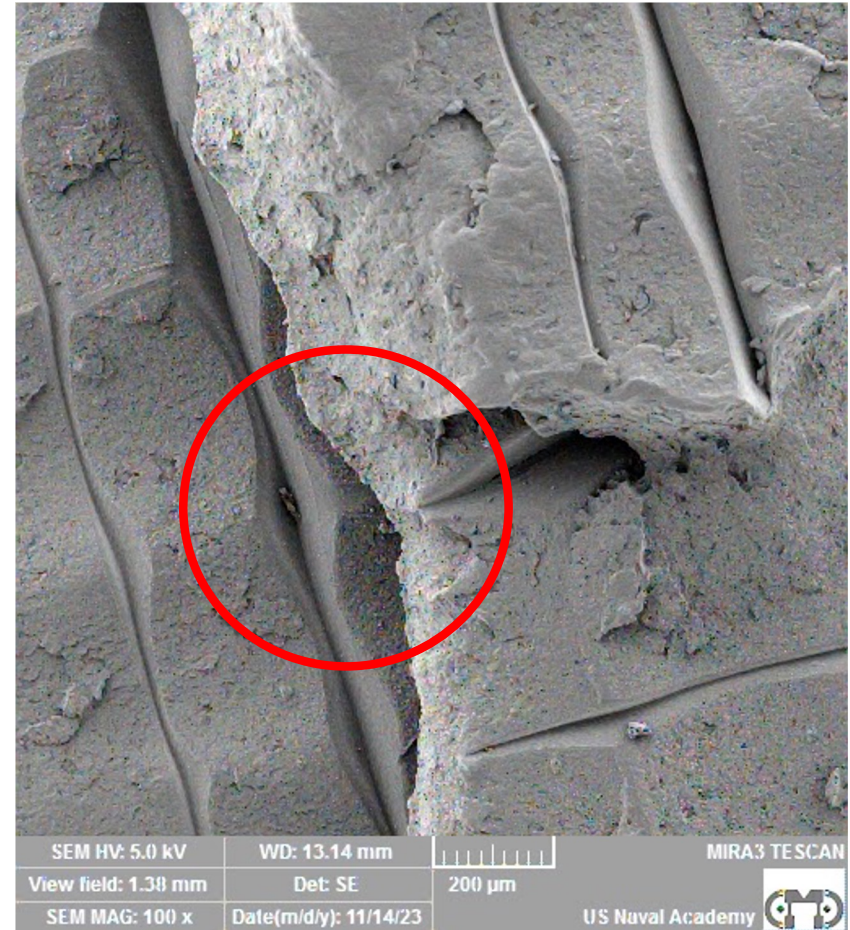


credit: <https://www.mdpi.com/2073-4360/15/1/28>





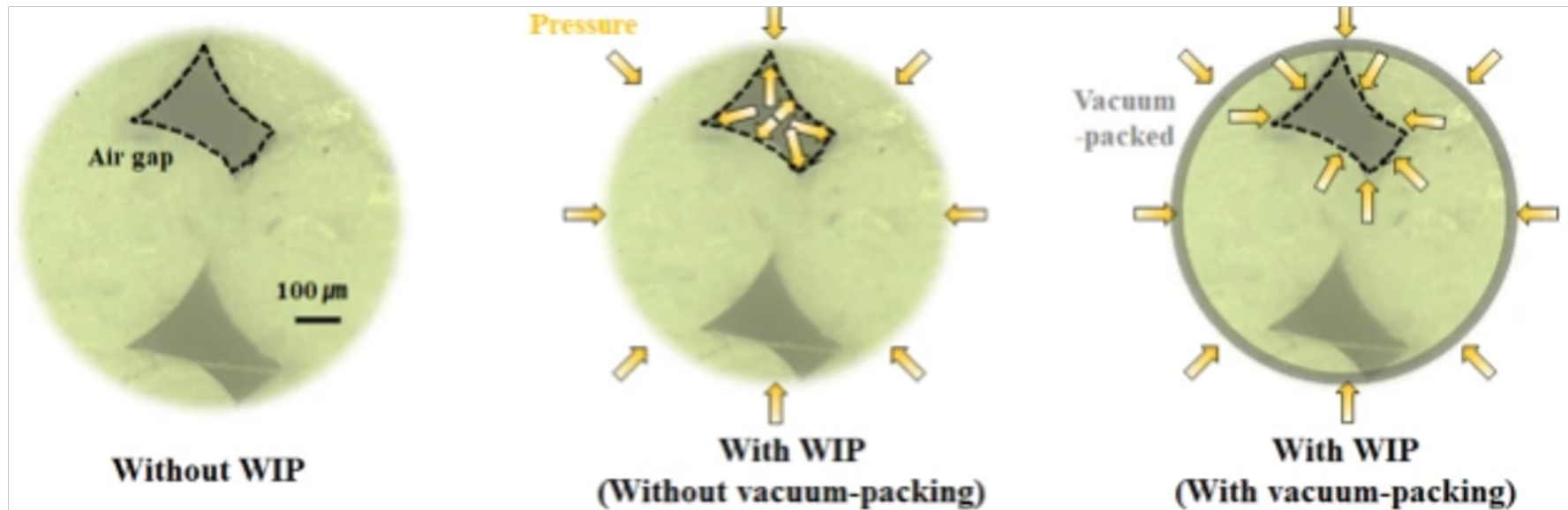
# SEM: Microvoids





# Solution: Warm Isostatic Press

- Sustained constant heat + pressure to close microvoids
- Process designed by Park et al.
- Temperature near glass transition temp



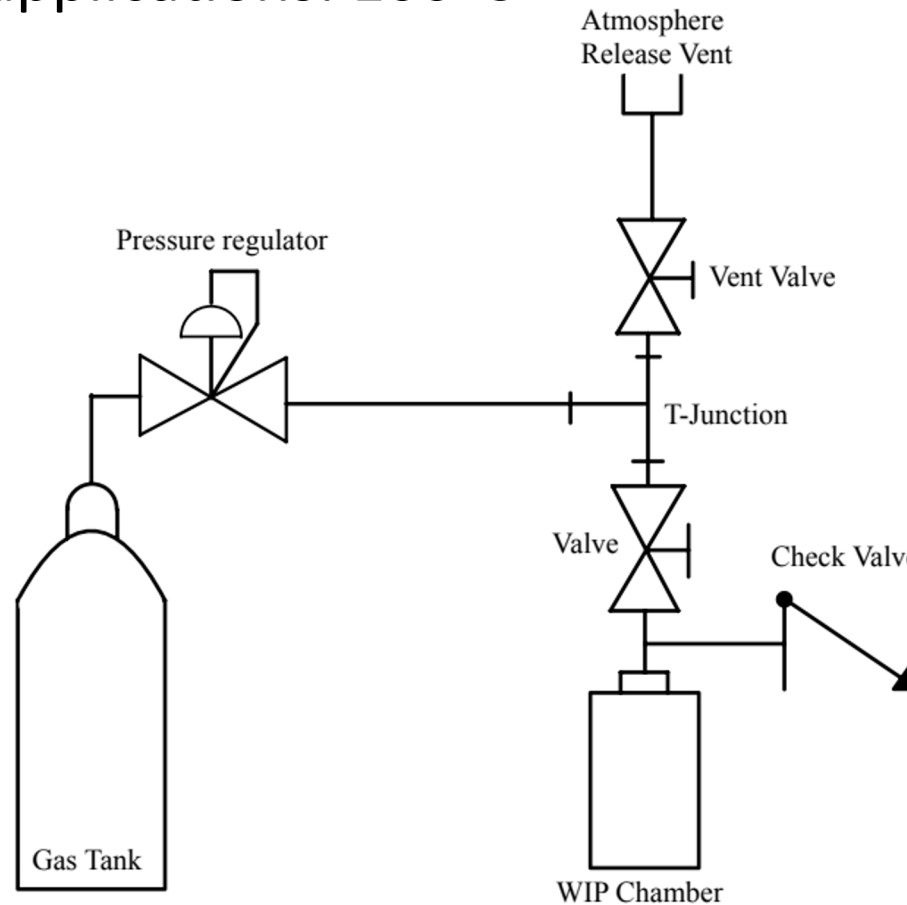
credit: <https://link.springer.com/article/10.1007/s00170-022-10094-6>



# Warm Isostatic Press



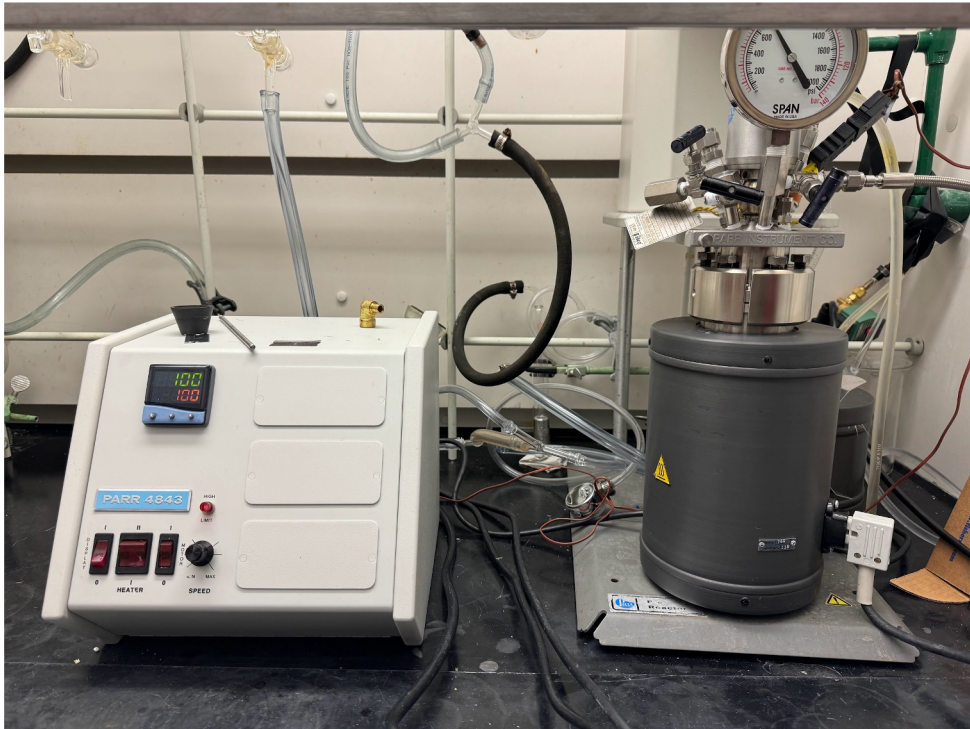
- Pressure from nitrogen gas tank
- Temperature from heat controller typically used for chemistry applications: 100°C
- 1 hour







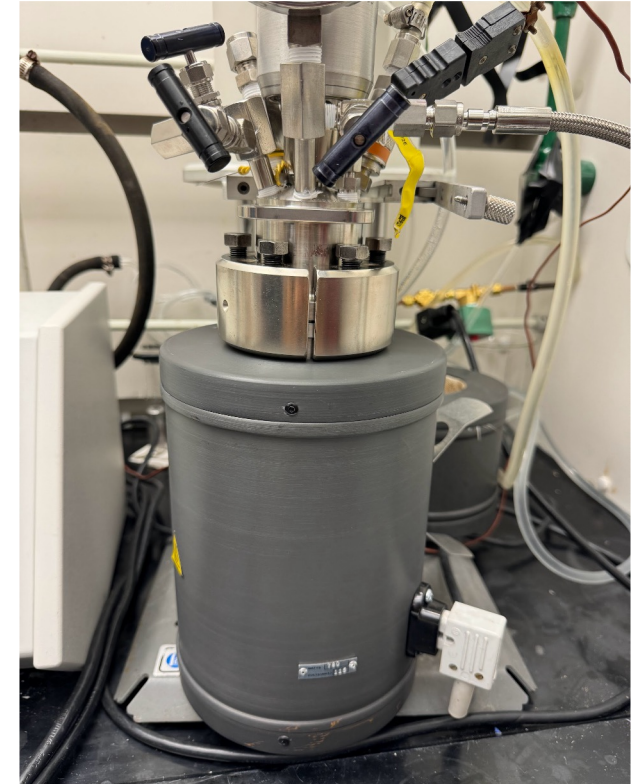
# Warm Isostatic Press







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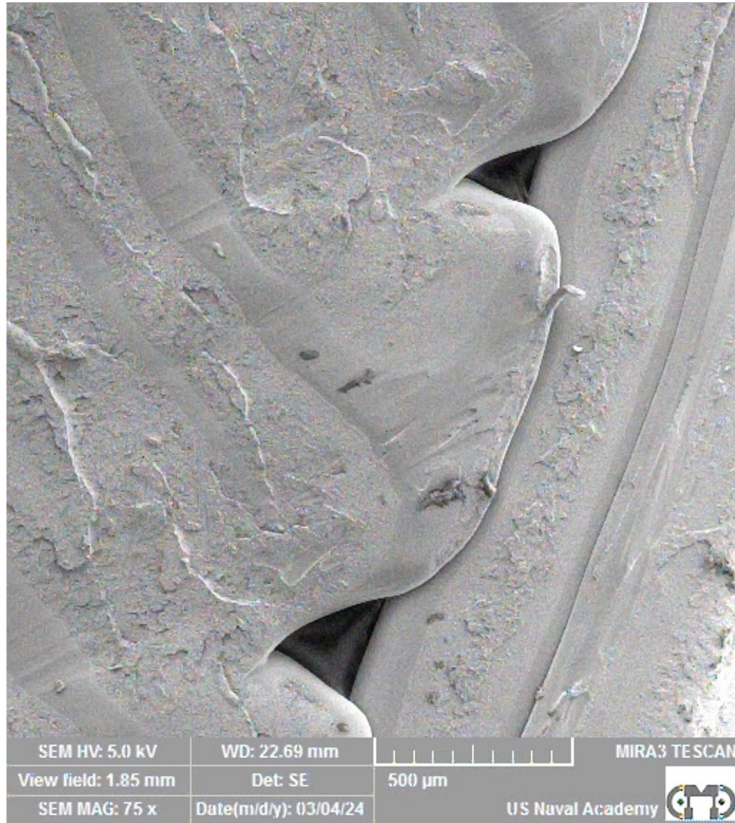




# Results



750 psi



1300 psi



Samples with 1300 psi WIP averaged an increase in density by 3.1%.





# Conclusion and Future Work

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- WIP is effective in closing microvoids of AM parts
- Need to find ways to preserve shape and structure throughout WIP
  - Center slot
  - Interior geometries
- If microvoids close, we have a potential to reduce AM-induced outgassing and increase feasibility of AM parts on CubeSats



# Works Cited

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- Napoli, Matthew. *The Use of Additive Manufacturing Technologies for the Design and Development of a Cubesat*. May 2013. <https://www.sjsu.edu/ae/docs/project-thesis/Matthew.Napoli-S13.pdf>
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- CRP Technology. *Windform XT 2.0*. <https://www.windform.com/sls-materials/windform-xt-2-0/>
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# Questions?

