Prospects of Additive Manufacturing for Accelerators

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Introduction

Additive manufacturing allows the production of mechanical components often much faster than traditional manufacturing. Several accelerators components built using additive manufacturing have already been qualified for use in accelerator. A workshop was held in Orsay in December 2018 to discuss the prospects of using additive manufacturing for particle accelerators and particle detectors. We report here on the prospects as far as accelerators are concerned.
The programme of the workshop and the presentations given at that occasion are available at `http://programme.i3d-metal.fr/`

Advantages and challenges

Advantages and techonological challenges of i3D manufacturing at accelerators

Advantages:

- Topological optimisation
- New shapes:
  - Embedded cavities
  - Colling channels
  - Mesh structures
- More economical on complex parts
- Faster
- More accurate
- Repair old parts

Challenges:

- UHV compatilibility
- Electrical conductivity
- RF
- New materials
- New alloys
- Multi-materials
- Mechanical strength

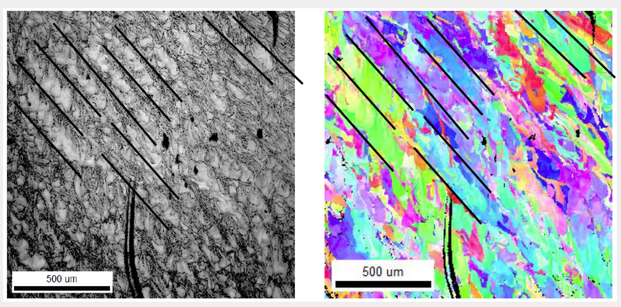
Issues:

- Postprocessing
- Surface quality
- Machine to machine reproductibility

Tensile strength

Studies are ongoing to understand the tensile strength of samples printed using metal additive manufacturing. Different printing processes have been used to allow comparison. **For more detail see WEXXPLS3 during this conference**.

Several samples printed using additive manufacturing with different machine settings or sample orientation. Source: Stéphane Jenzer (LAL, Orsay).

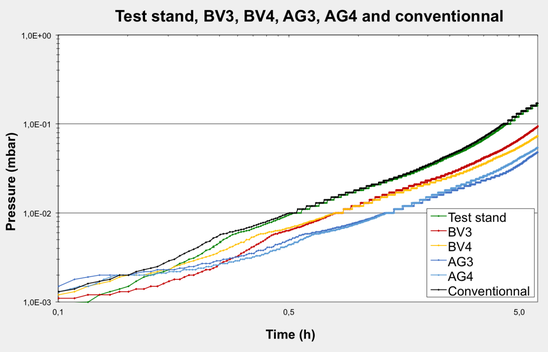


Electronic Microscope image of some 3D printed samples, showing the growth direction of the cristals. Source: Gael Sattonay (LAL, Orsay).

Ultra-High Vacuum

Studies have been done to test the Ultra-High Vacuum compatibility of beam pipes produced by additive manufacturing. These beam pipes where then UHV tested and their compatibility was confirmed by the LAL UHV group.

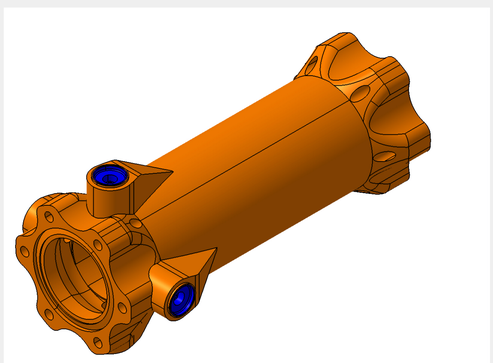
Beam-pipes after they have been produced by additive manufacturing and before they were removed from the support (source: IPAC'17 WEPVA043).

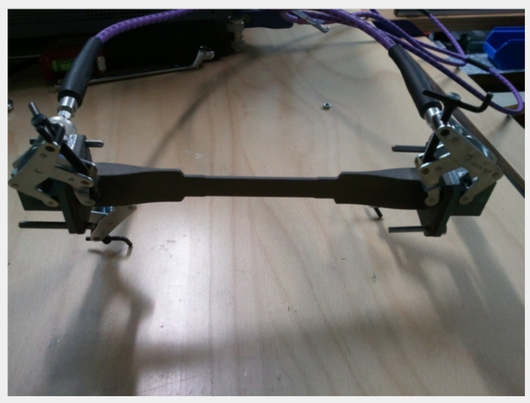


These beam pipes were UHV tested under static vacuum. The pressure increase was found to be comparable for the UHV samples and for the reference beam pipe (source: IPAC'17 WEPVA043).

Electrical conductivity : BPM, antenna, cavities,...

Several components have been produced that test electrical performances of components produced by additive manufacturing.





Left: Beam Position Monitor produced by additive manufacturing and tested in an accelerator beamline (see IPAC'18 THPAL016 and this conference FRXXPLS1).
Center: RF measurement of an additively manufactured waveguide (Source: Alexej Grudiev, CERN, `https://indico.cern.ch/event/275412/contributions/1617680/`).
Right: A niobium cavity manufactured in Niobium (source: Romain Gerard, CERN).

References

- IPAC'17 WEPVA043
  Study of the suitability of 3D printing for Ultra-High Vacuum applications
- IPAC'18 THPAL016
  Study of the Performances of a 3D Printed BPM
- IPAC'19 WEXXPLS3
  Is It Possible to Use Additive Manufacturing for Accelerator UHV Beam Pipes ?

Conclusion

- Significant work is ongoing to qualify additive manufacturing for particle accelerators.
- Some impressive results have been produced in the past year.
- Addditive manufacturing allows optimized shapes and complex features.
- Some challenges still to be addressed.

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