FUTURE CIRCULAR COLLIDER

SPECIAL TECHNOLOGIES WP4

Manufacturing technologies

Additive manufacturing for vacuum systems

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26th April 2017

Administrative

Collaboration with Mines ParisTech : Study of cold spray coating for applications in Ultra-High Vacuum:

- 1 PhD student at Mines ParisTech, starting in October 2017
- DR-6657779/TE approved
- Agreement with purchasing service to split the project in two
- MoU to be signed by Mines ParisTech and Armines
- Addenda to be written

Technical aspects

Vacuum performance:

- Tightness,
- Thermal outgassing,
- Coating ability,

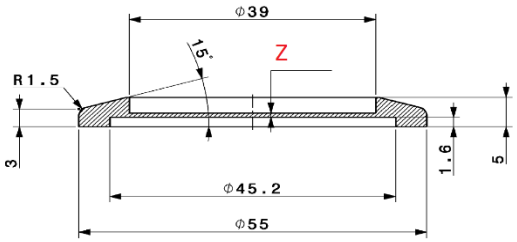
of materials:

- Stainless steel,
- Titanium,
- Aluminium,
- Copper,

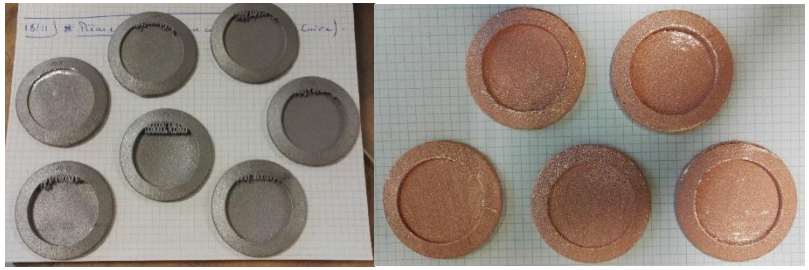
manufactured by different additive manufacturing methods:

- Direct Metal Laser Sintering (DMLS),
- Electron Beam Melting (EBM),
- Cold Spray (CS).

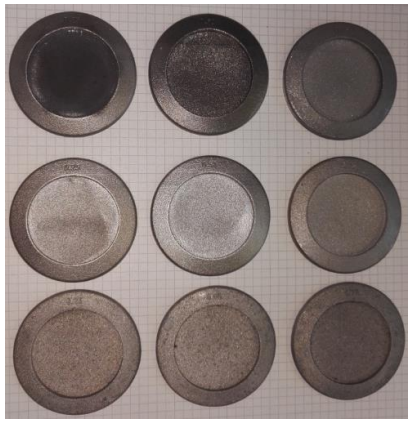
Tightness of thin walled components



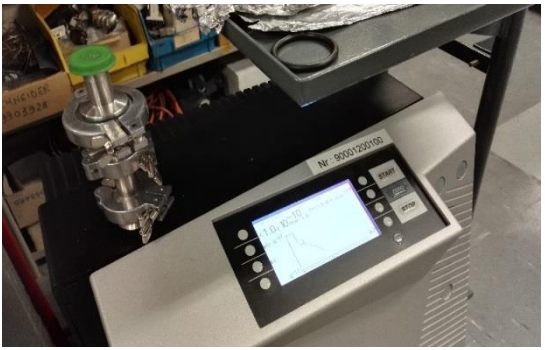
Sample geometry



Ti and Cu EBM-made Thin-Wall Samples



StSt, Ti and Al DMLS



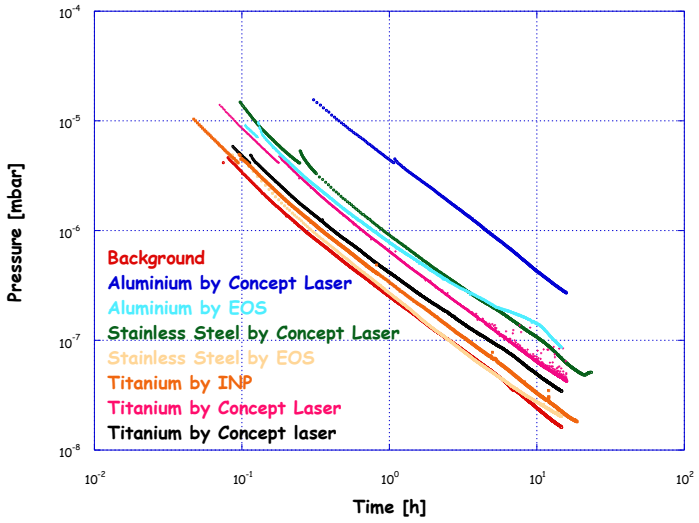
Set-up (leak detector)

Material	Process	Manufacturer	Heat Treatment	Thickness (mm)	Orientation	Leak Tight
Ti6Al4V	DMLS	Initial	No	0.25/0.50/0.75	xy	NO
			HIP	0.25/0.50/0.75	xy	YES
		3T	No	0.25	xy	NO
			No	0.25	z	YES
			No	0.75 to 2.5	z	YES
			No	0.50/0.75/1	xy	YES
			No	0.50 to 2.5	45	YES
	EBM	AIDIMME	No	0.25	xy	NO
			No	0.5 to 2.5	xy	YES
Cu	EBM	AIDIMME	No	0.5/1	xy	N/A
			No	1.5/2/2.5	xy	NO
316L	DMLS	Initial	No	0.25/0.50/0.75	xy	YES
AlSi10Mg	DMLS	Initial	No	0.25/0.50/0.75	xy	NO
			HIP	0.25	xy	N/A
			HIP	0.50/0.75	xy	YES

Summary table

Thermal outgassing

Pump down curves



Material	Supplier	Pressure @ 10h [mbar]	Degassing [mbar l/s cm2]
Background		$2.4\ 10^{-8}$	$3.4\ 10^{-10}$
Aluminium	Concept Laser	$4.3\ 10^{-7}$	$2.1\ 10^{-8}$
Stainless Steel	Concept Laser	$1.1\ 10^{-7}$	$4.4\ 10^{-9}$
Titanium	Concept Laser	$6.3\ 10^{-8}$	$2.1\ 10^{-9}$
Aluminium	EOS	$1.4\ 10^{-7}$	$6.3\ 10^{-9}$
Stainless Steel	EOS	$2.7\ 10^{-8}$	$<2.6\ 10^{-10}$
Titanium	EOS	$4.9\ 10^{-8}$	$1.4\ 10^{-9}$
Titanium	AIP	$3.3\ 10^{-8}$	$4.6\ 10^{-10}$

The reference value for stainless steel is $3\ 10^{-10}$ mbar.l.s^{-1}.cm^{-2}

Accumulation after bake out (150°C, 24 h)

Material	Supplier	Hydrogen [mbar l/s cm2]
Aluminium	Concept Laser	$1.1\ 10^{-13}$
Stainless Steel	Concept Laser	$8.0\ 10^{-13}$
Titanium	Concept Laser	$4.9\ 10^{-14}$
Aluminium	EOS	$6.8\ 10^{-14}$
Stainless Steel	EOS	$1.1\ 10^{-12}$
Titanium	EOS	$2.9\ 10^{-14}$
Titanium	AIP	$2.4\ 10^{-14}$
Titanium	3D	$7.7\ 10^{-13}$