Growth of a compact thermoelectric generator based on multi-disciplinary approach

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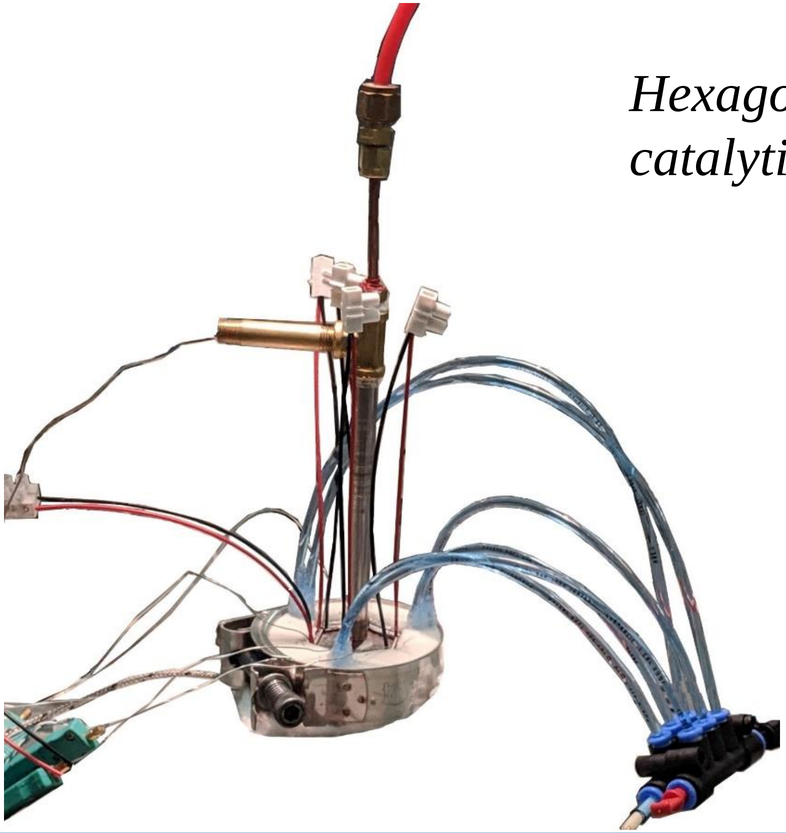
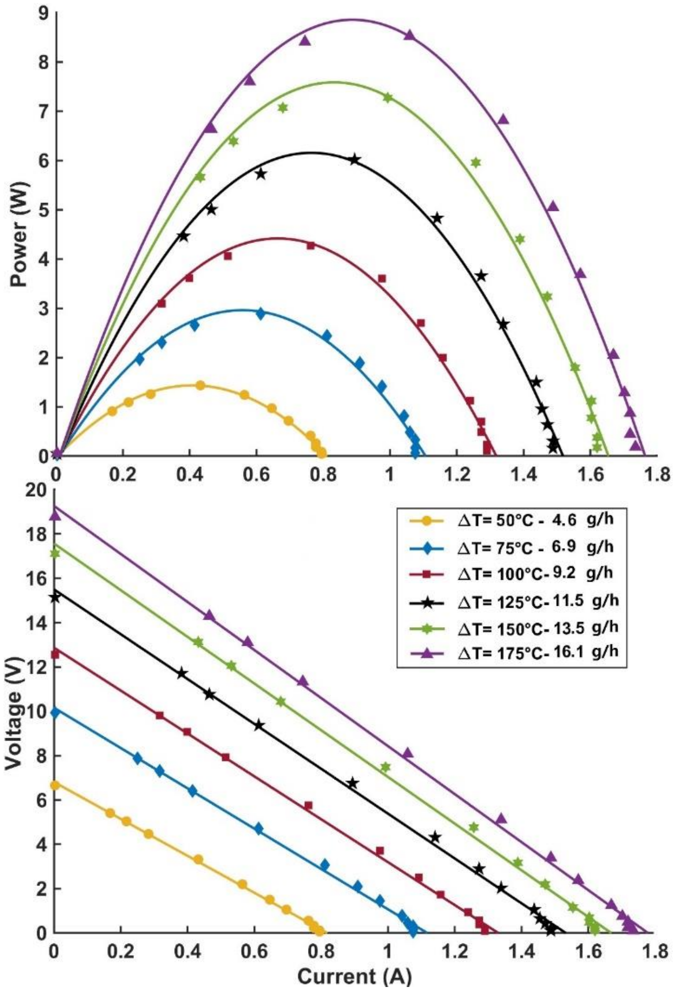
An ICMATE Institute of Condensed Matter Chemistry and Technologies for Energy *team*

Let's start from the end…

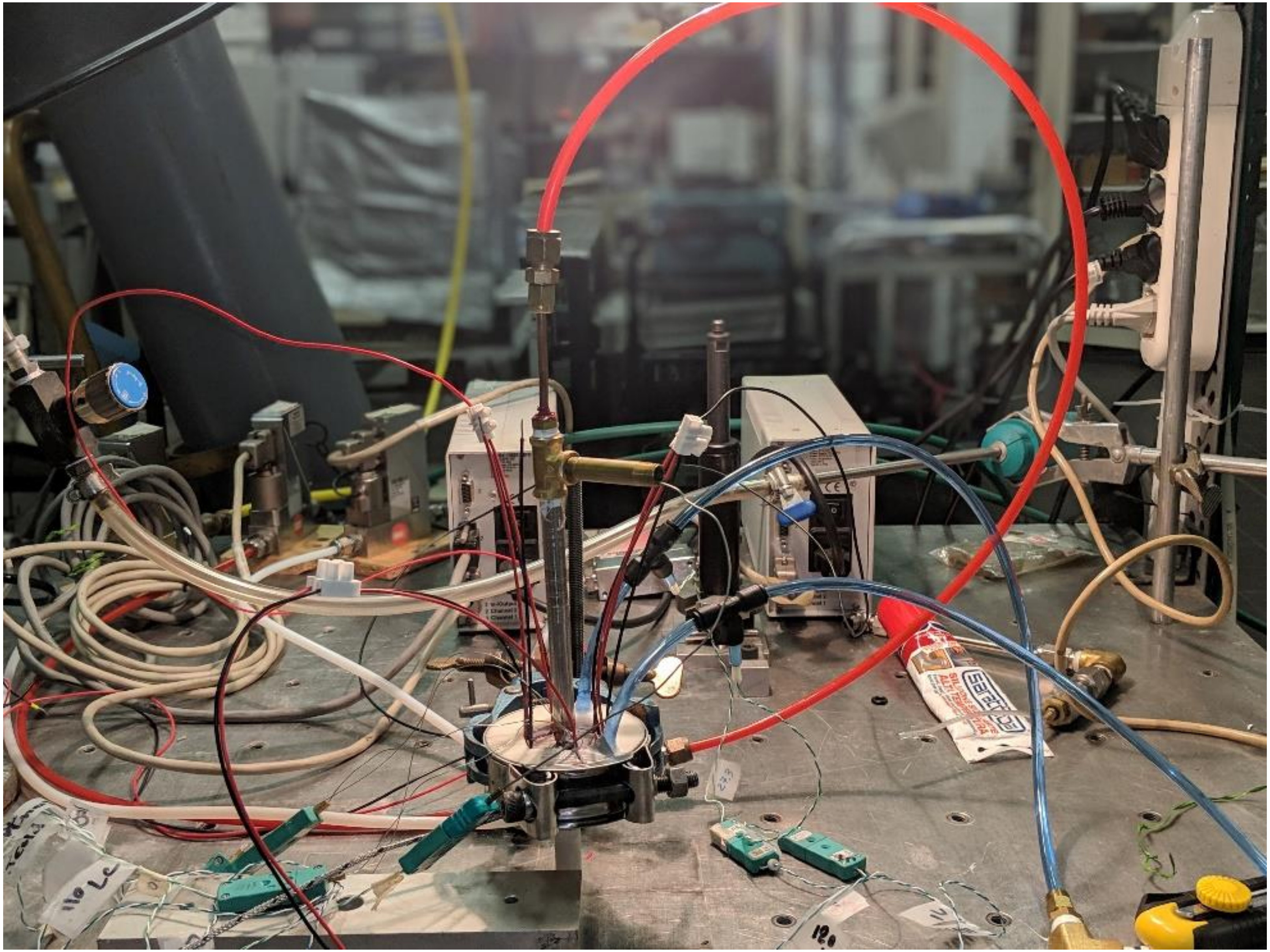


Hexagonal thermoelectric generator based on catalytic combustion of propane/air mixture

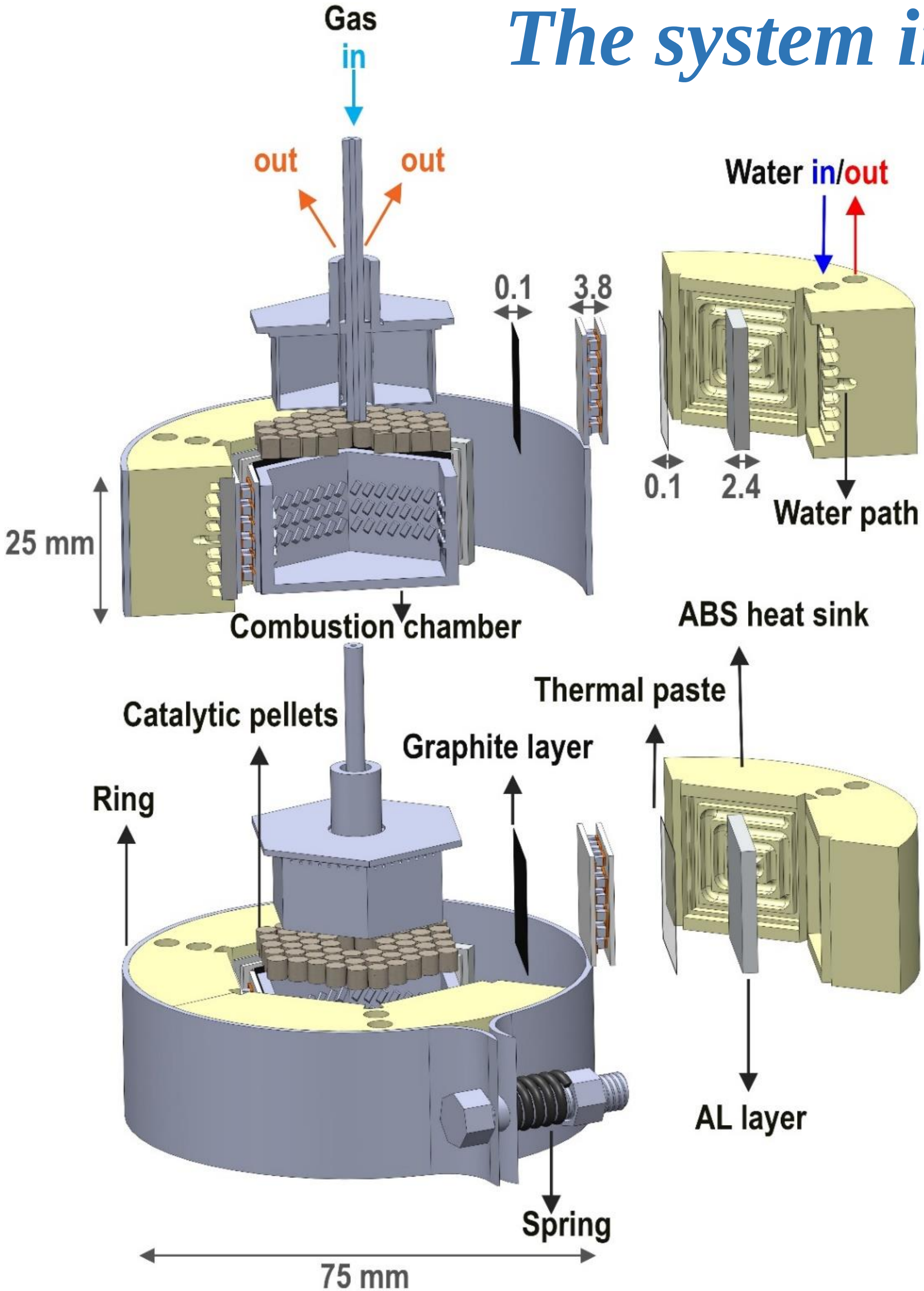


Max performance measured at ΔT = 175°C (T_{hot} = 230°C, T_{cold} = 55°C)	
Electrical power output	8.6W (8.1V, 1.1A)
Propane consumption	16 g/hr
TE conversion efficiency	4%
Overall efficiency	3.5%

Easy data, but a complex test facility



The system in details

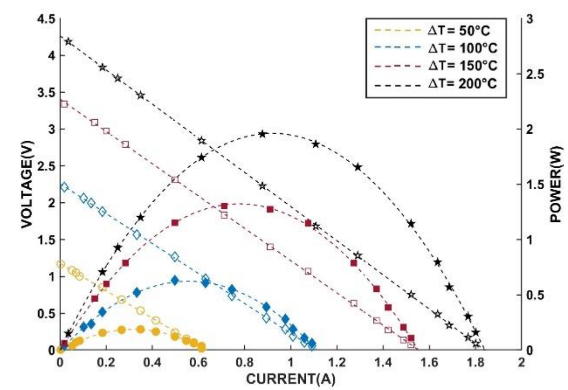


The cold stage

ABS water-cooled heat exchanger (48g + 24g)

The power converter

Commercial TE modules (6) mounted in series (25g)



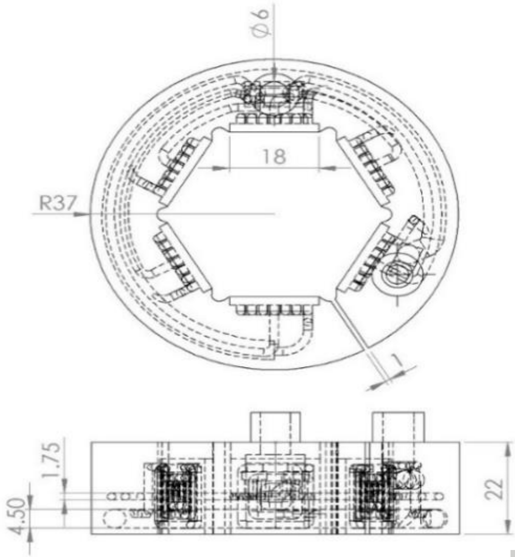
The hot core

SS hexa box with finned walls and shaped cap + 52 catalytic pellets (Pt on Alumina) (75g)

The cold side of the TEG: a light solution

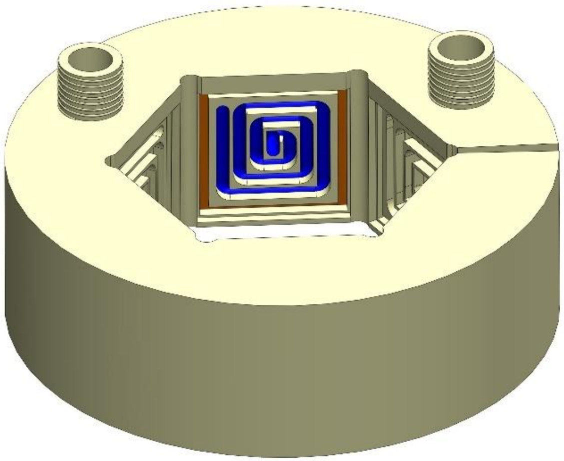
Additive tech enables the possibility to print complex ideas using a wide palette of materials

The idea…



The material needs:

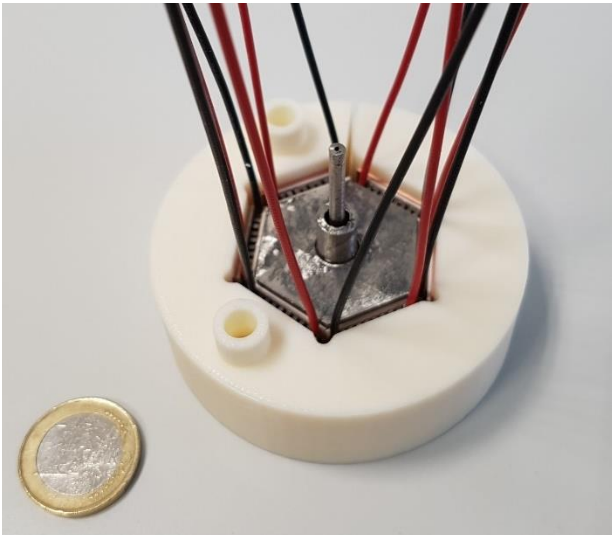
- Light and resistant
- Waterproof
- Thermal conductive

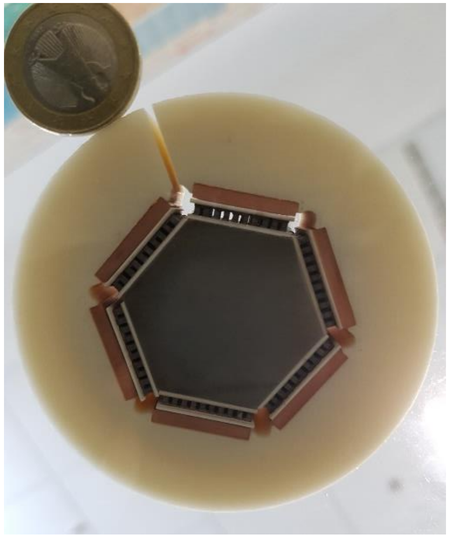


The choice

ABS + Cu/Al

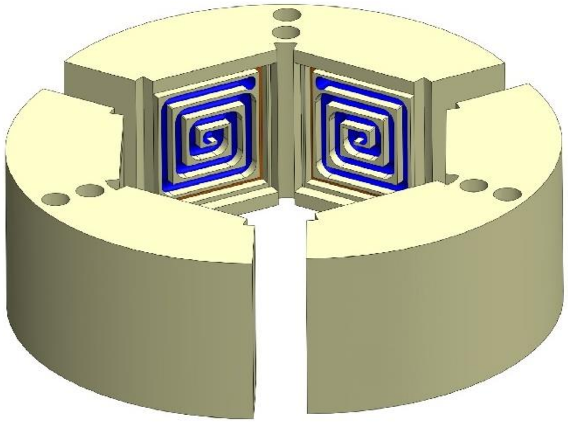
…and the 1st failures





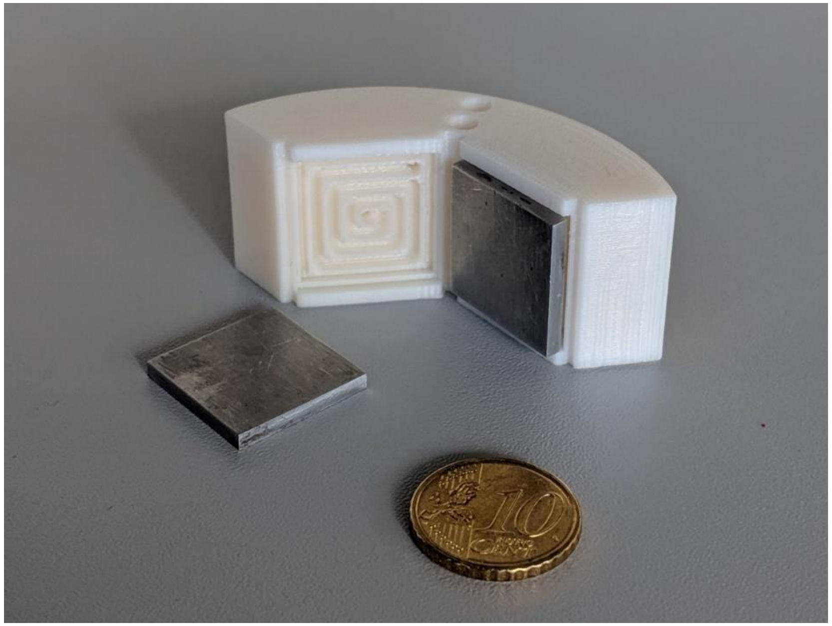
The cold side of the TEG: a light solution

… up to an operating solution



Segmented structure

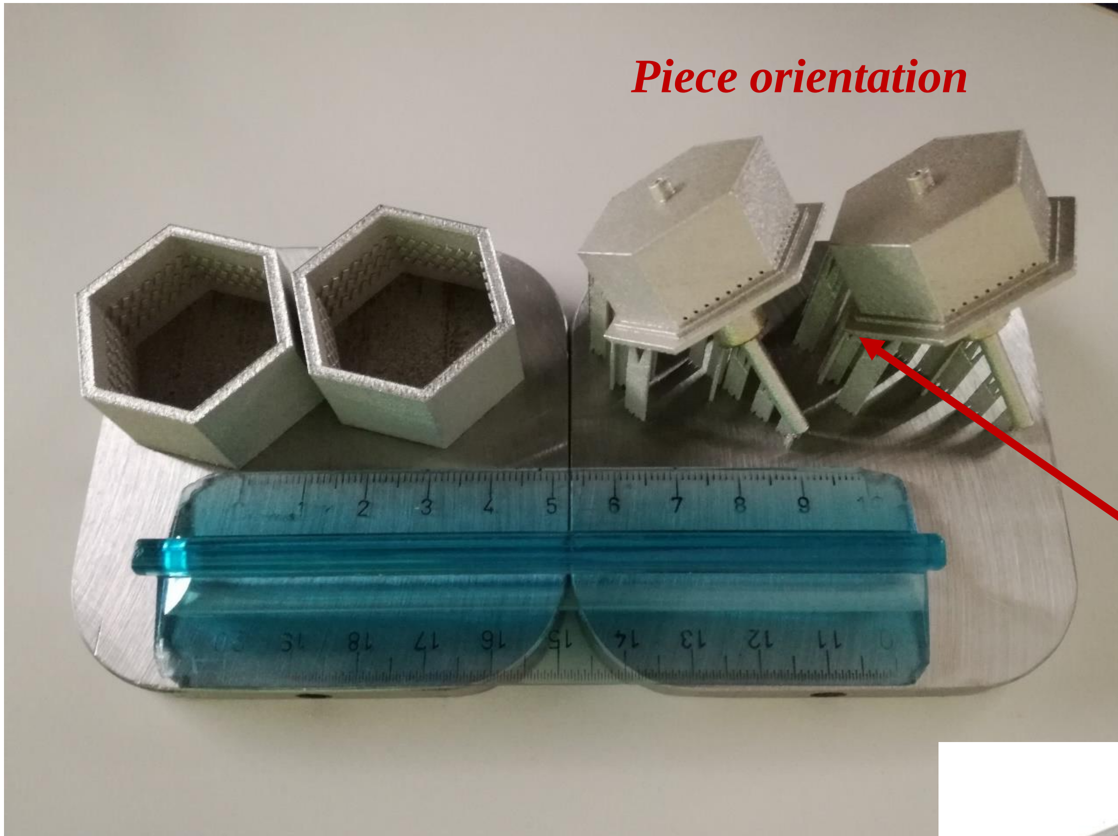
- More effective in imposing the homogeneous pressure on the TE modules



- Easy to handle for the processes required to attach the Al plates and to waterproof the device

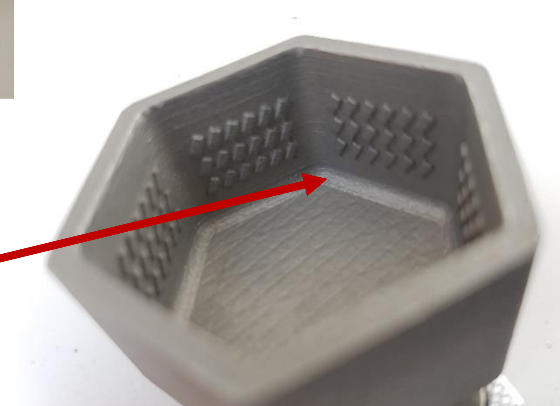
- Higher reliability in the assembly of the TEG in terms of prevention of surface cracks and flexibility in system arrangement

The hot core: the combustion chamber
- Selective Laser Melting -



The Process
Components are grown, layer by layer, laser melting SS powder following a 3D model

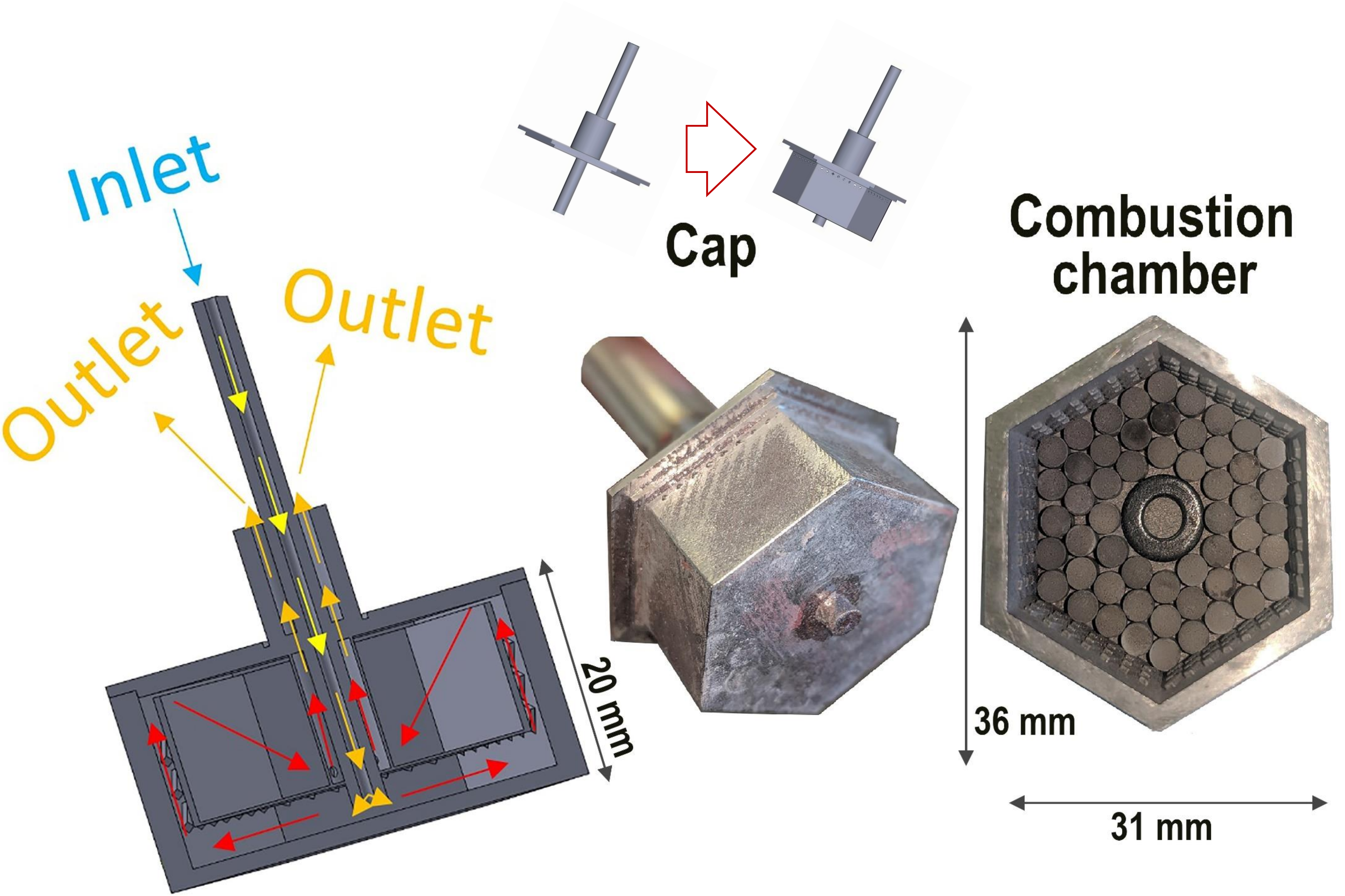
The Project
The process has to be designed in order to allow the build of the cavities reducing the supporting material



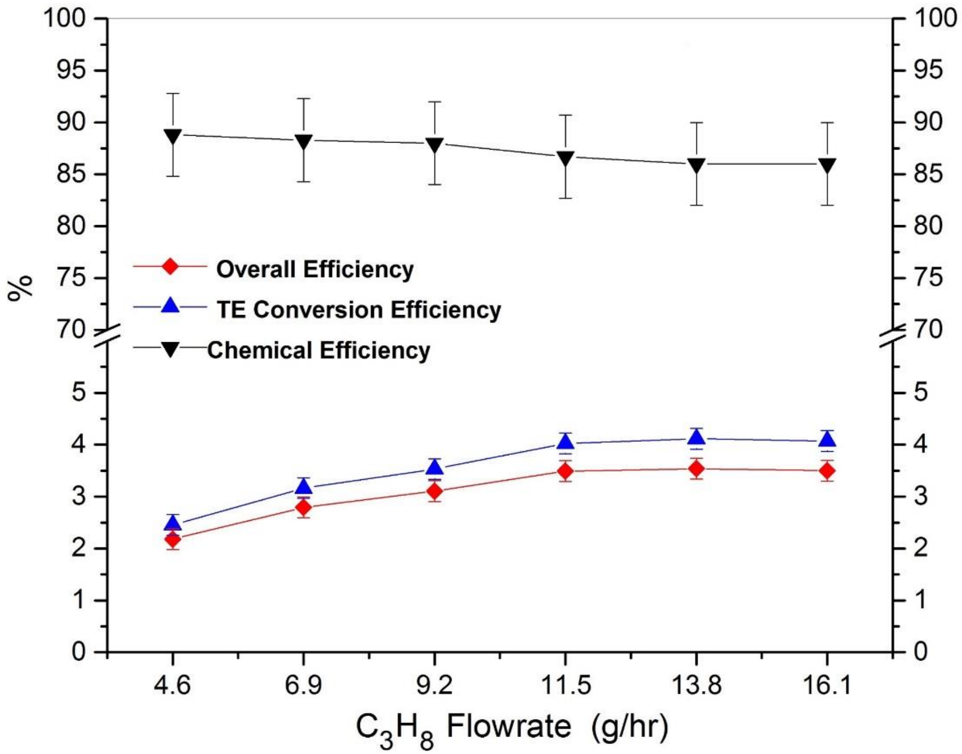
Thermal profile homogenisation

The Extra
The process allow the creation of embedded structures useful to enhance the device performance

The hot core: the combustion chamber



The efficiency

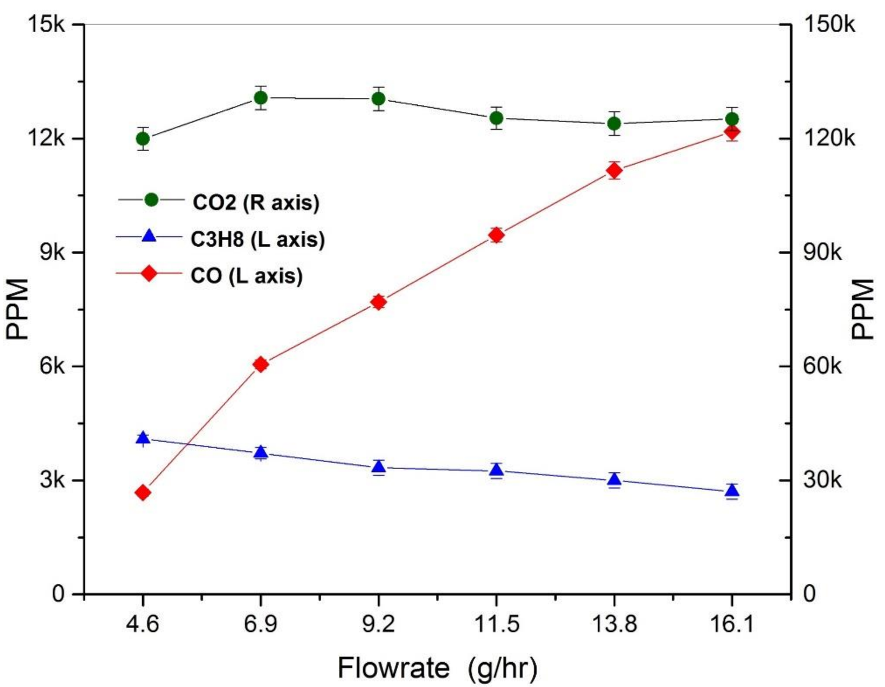


The characterisations

Thermal and electrical powers involved in the system are characterised along the generator chain. The analyses are performed varying the operating regimes imposing constrains related to safety and portability of the device.

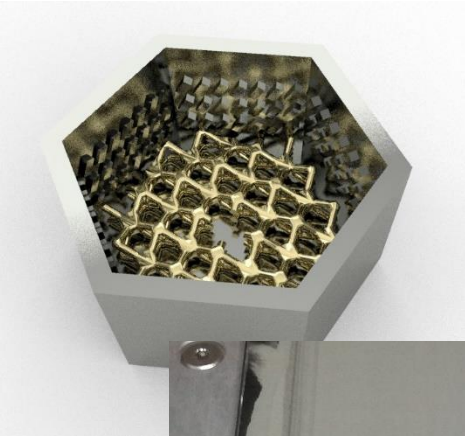
Understanding the direction

FTIR analyses allow the evaluation of the chemical efficiency of the burning process. It also offers a crosscheck of TE conversion efficiency deduced by thermal analyses.



Facing efficiency: our own catalyst

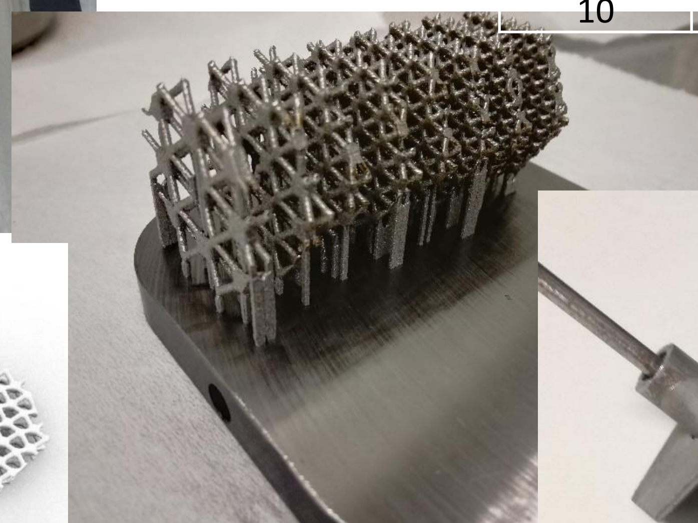
- An alternative structure -

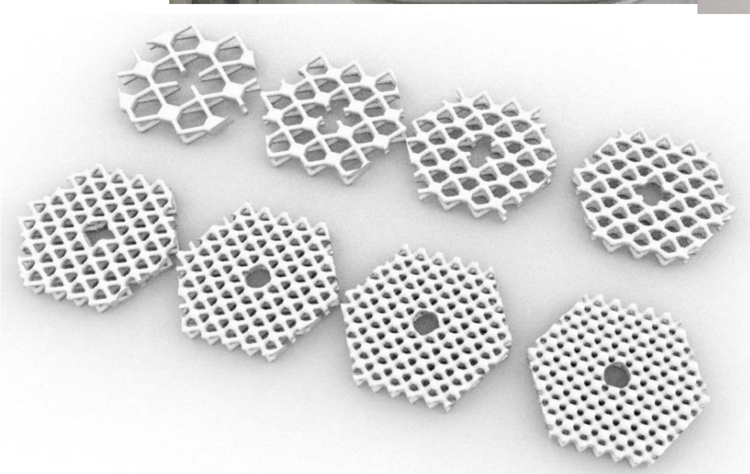


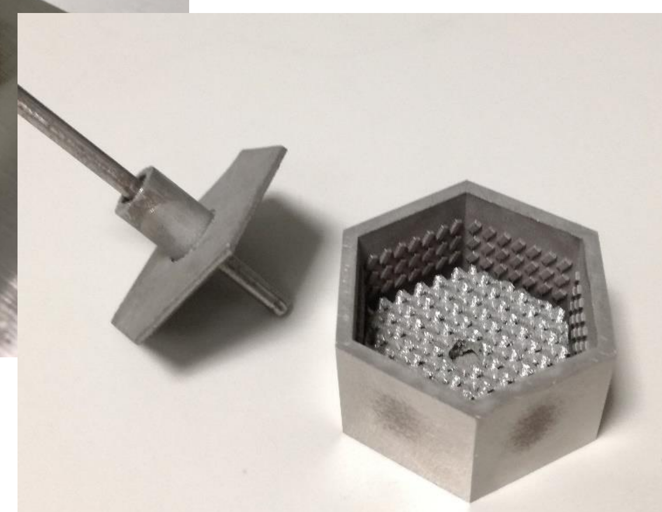
Additive again!
Active surface enhancement

$S_{pellets} = 1705\ mm^2$
$S/V = 1.25\ mm^{-1}$

no. Cells	Surface [mm²] (from CAD)	Volume [mm³] (from CAD)	S/V [1/mm]
3	987	311	3.18
4	1274	382	3.34
5	1502	430	3.49
6	**1763**	**501**	**3.52**
7	**2025**	**573**	**3.53**
8	**2297**	**653**	**3.52**
9	2566	746	3.44
10	2804	869	3.23



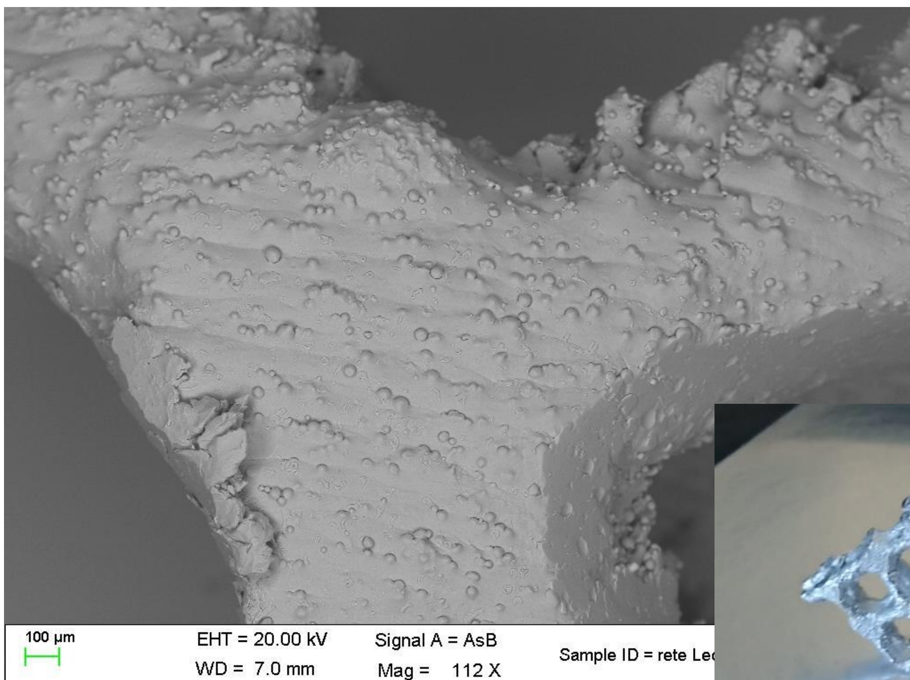


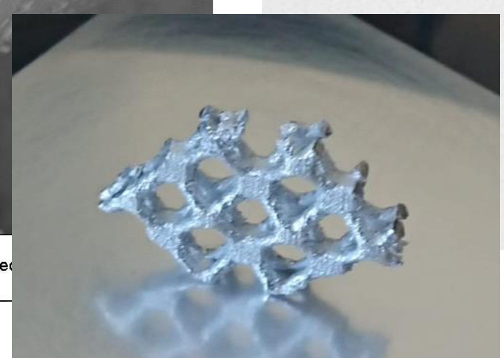


Facing efficiency: our own catalyst

- The catalyzer deposition-

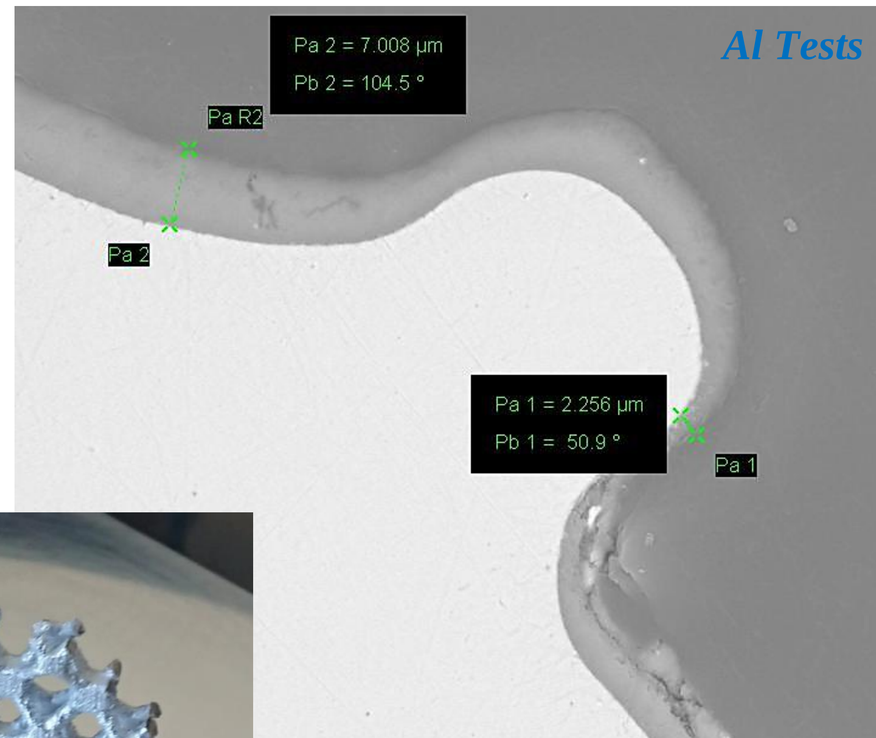
Complex surfaces to be treated



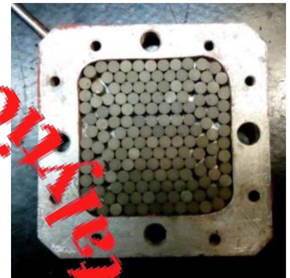


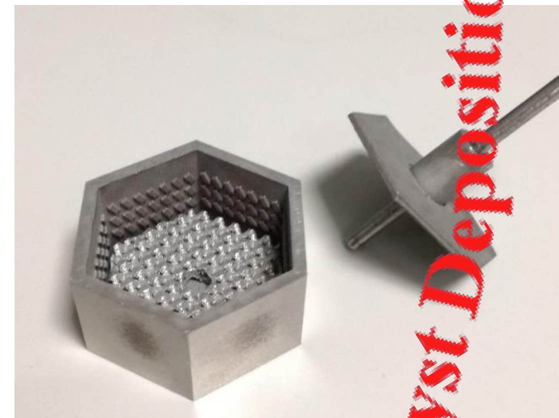
Available techniques able to produce a regular catalyst layer:

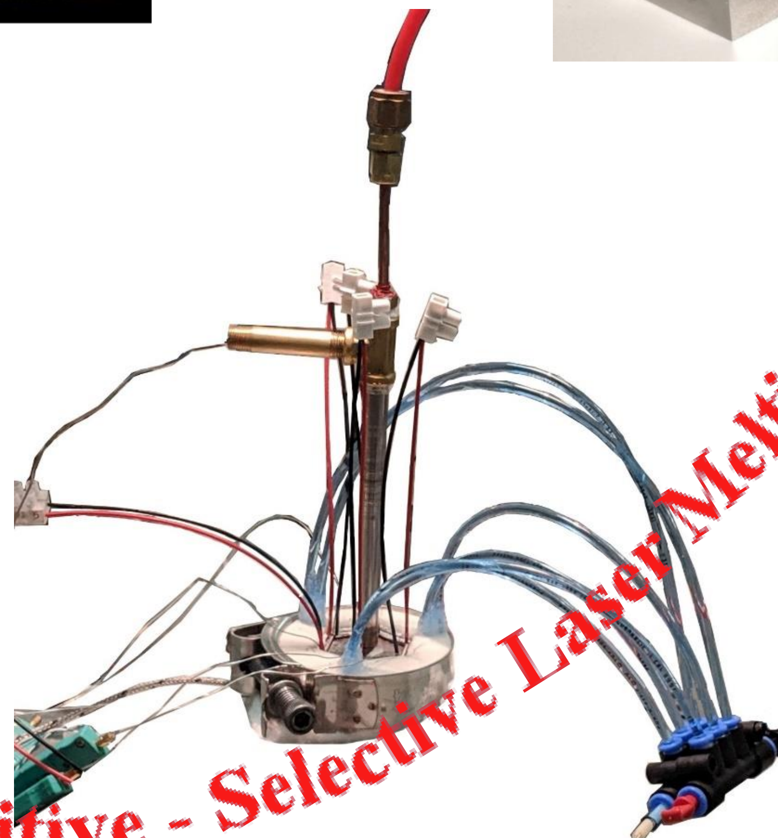
- *CVD*
- *HiPIMS*



And the story goes on…







Catalytic Combustion - Thermoelectric Modules - ABS Additive - Selective Laser Melting - Catalyst Deposition