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Electronic Supplementary Information – communication

1. Experimental section
   1.1. Building of SLM lattices

The metallic powder of Inconel 625 was purchased from Renishaw plc. The powder composition was obtained by ICP-AES analysis and shown in Table *1*. The lattices were built with a SLM Solutions SLM125 system equipped with a single 400W fibre laser. The powder was placed in an Argon atmosphere on the build plate preheated at 200°C and a laser power of 200W was used to melt the successive layers of 0.03 mm thick with a scan speed of 900 mm/s, a laser spot size of around 80 µm and a hatch spacing of 0.12 mm.

Ni	Cr	Mo	Fe	Nb	Mn	Si	C	Ti	Al	S	P	Cu	V	Co	W
62.46	20.80	8.65	4.16	3.45	0.01	0.13	0.02	0.16	0.11	0.01	0.01	0.01	<0.01	0.02	/

Table 1: Composition of Inconel 625 (in wt%) determined by ICP-AES

   1.2. Catalyst coating

The catalyst coating on the Additive Manufactured lattices has been deposited thanks to an organic binder, an inorganic binder, and a solvent. The inorganic binder allows to improve the suspension of catalyst particles in the slurry used to coat the lattices, and the organic binder allows to fill the void between the bigger catalyst particles during the coating step, which will lead to an increased stability. Before coating, all the SLM lattices were first calcined in air with a ramping temperature of 8°C/min until reaching 500°C kept at this temperature for two hours. For each catalyst coating, a slurry was prepared where 5 g of polyvinylalcohol was added to 75 g of deionized water and kept at 45°C under magnetic stirring until complete dissolution. 15g of catalyst (HY30, HY30Al or HY30AP respectively) and 5g of alumina powder were added to the solution and dissolved by mechanical shaking. 1 mL of glacial acetic acid was then added drop by drop during constant stirring until complete dissolution and the obtention of a homogeneous slurry. The lattices were submerged in the solution overnight, dried at 100°C and sonicated to remove any residual non coated catalyst particles. The lattices were individually weighted before and after the deposition to determine the amount of deposited catalyst particles on each support. The lattices were found to weight 2.6 g before deposition, and the average amount of deposited catalyst particles was found to be 9 mg.

1.3. Characterization techniques

The X-ray Diffraction (XRD) patterns were obtained with a Bruker D4 Endeavor wide angle XRD spectrometer using a Cu Kα source with 40 KV. The Scanning Electron Microscope (SEM) images and the EDX composition analysis were obtained with a FEI Nova NanoSEM 200 FEGSEM with a Through Lens detector. The near surface of the samples was analysed by a Thermo Scientific K alpha XPS with a monochromatic Kα ray source.

1.4. Catalytic testing

The catalytic cracking of methylcyclohexane was performed in a fixed-bed benchscale reactor. The SS reactor tube has an ID of ½'' while the SLM lattices were built slightly narrower to fit in the reactor while avoiding any spacing between the lattice and the inner wall of the reactor. The SLM lattice was fixed in the middle of the reactor thanks to quartz wool and the remaining volume in the reactor tube was filled with inert SiC. The samples were initially preheated in an Argon flow at 30 sccm at 500°C during half an hour before performing the catalytic reaction. The reactant was vaporised by mixing Methylcyclohexane (Sigma Aldrich, 99% anhydrous) Argon (BOC, High purity grade) thanks to a vaporizer (Kemstream, Vapbox 300) at 0.15g/min and 30 sccm respectively with a partial pressure of p_{MCH} = 0.55 atm. The vaporised methylcyclohexane (MCH) was sent to the reactor lines through preheated lines to avoid condensation and the first zone of the furnace was preheated at 500°C to preheat the reactant at the reaction temperature. The products and unreacted MCH were condensed and both the condensed liquid phase and the remaining gas phase were collected at regular intervals.

The single reaction performed in supercritical conditions was performed in the same reactor setup with a different injection system. Pressurized MCH contained in a Parr vessel was sent to the reactor thanks to a Bronkhorst mini-CORI Mass Flow Controller at $_{FMCH}$ = 6 g/min and a reactor pressure of 40 bar, held by a Back Pressure Regulator (Swagelok, KPB series) installed upstream to the condensation system.

1.5. Product analysis

The gas and liquid products were analysed by Gas Chromatography – Mass spectrometry (GC-MS) with an Agilent 7000C GC-QQQ equipped with a 30m Agilent J&W DB5-ms column for product characterization. Gas Chromatography was performed to determine the MCH conversion and hydrocarbon selectivity thanks to an Agilent 6890N with FID detector with a 30m Agilent J&W DB5-ms column. The hydrogen production was determined by analysing the gas samples with a Perkin Elmer Clarus 580 with TCD detector.

The MCH conversion was determined based on the unreacted amount of MCH in the liquid and gas samples and an internal standard (n-decane) was added to the liquid samples for calibration and determination of the conversion. The MCH conversion was determined as follow:

$$Conversion(wt\%) = \left(\frac{Reactant\ mass_{sent\ to\ reactor} - Reactant\ mass_{unreacted\ in\ liquid\ and\ gas\ samples}}{Reactant_{sent\ to\ reactor}}\right) x\ 100$$

The selectivity of hydrocarbon products is determined based on the peak area obtained by GC-FID:

$$S_{product\ i}(wt\%) = \left(\frac{peak\ area_{product\ i}}{\sum peak\ area_{product\ i}}\right) x\ 100$$

The hydrogen production is determined thanks to external calibration where three certified gases in the range of the hydrogen quantity contained in the gas samples were injected prior to the analysis. The GC-TCD was equipped with a sampling loop to account for the same amount of gas sent to the detector at every experiment.

2. Supplementary figures

Figure 1: hypersonic engine inlet nozzle with integrated fuel cooling channels, designed by SLM *(*P. Dunne, "Innovating for efficiency with additive manufacturing in aerospace," *3D Printing & Additive Manufacturing Intelligence*, 2020. [Online]. Available: https://www.tctmagazine.com/additive-manufacturing-3d-printing-news/innovating-for-efficiency-additive-manufacturing-aerospace/)

3. Supplementary Results

3.1. Catalytic activity of zeolites in packed bed conditions

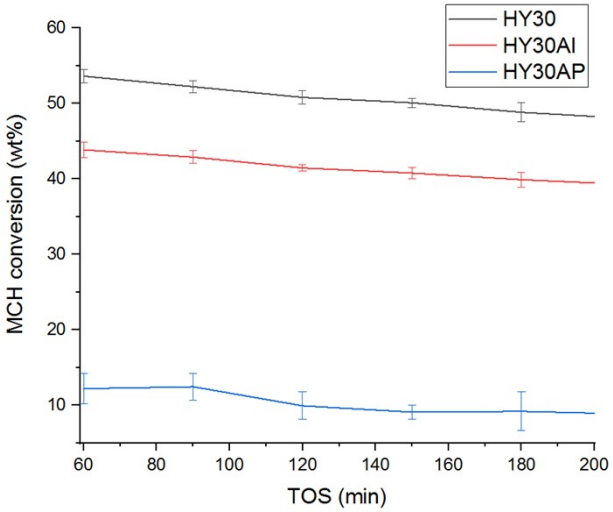

Figure 2: MCH conversion (wt%) in function of time-on-stream

The catalytic testing of 300 mg of catalyst (particles of 500-700 µm) have been tested in packed bed conditions, in the same operating conditions as for the SLM supports in this manuscript, hence in a fixed bed reactor at 500°C, with a mass flow of 0.15 g/min (p_{MCH} = 0.55 atm) and time-on-stream of 200 min.

3.2. EDX analysis

wt%	Inc	Inc Spent		Inc ox	Inc ox Spent	Inc HY30			Inc HY30 Spent		Inc HY30Al				Inc HY30Al Spent		Inc HY30AP			Inc HY30AP spent
Ni	49.3	55.1	57	56.5	57	42.9	42.3	40.1	42.2	43.7	46.4	44.2	43.7	47.5	51.4	47.8	47.3	47.2	45.8	
Cr	16.2	18.2	18.9	18.9	18.8	17.3	17.2	16.2	17.3	17.6	17.6	16	15.9	17.2	18.5	16.9	19.4	19.3	19.1	
O	4.1	4.2	4.4	4.7	4.4	12.6	13.9	14.2	14.1	12.4	12.2	14.4	14.5	11.7	7	9.9	11.6	12	12.8	
C	14.6	3.5		2.3	2.3	7.2	5.4	9	3.7	3.2	3.8	2.6	2.8	2.7	5	5.3	3.4	2.9	2.8	
Mo	6.2	8.1	7.4	8.4	7.3	7	6.9	6.5	6.7	7.9	7.7	7.5	7.1	7.3	6.9	6.4	7.8	7.2	7.8	
Nb	3.4	3.8	3.7	4.1	3.8	3.7	3.5	3.4	3.7	3.7	3.3	3.4	3.5	3.8	3.2	3.5	4.7	4.2	4.1	not
Fe	3.1	3.7	4	3.4	3.5	3.1	3	3.1	3.2	3.3	3.3	2.9	2.8	3.1	3.3	3.1	3.5	3.4	3.3	availabl
Si	0.3	2.1	2.5	0.2	1.2	2.8	4.1	3.5	4.6	4	2.2	3.8	4.3	2.4	1.7	3.2	0.8	1.3	1.9	e
Al	0	0.8	1	0.8	0.9	1.9	2.6	2.2	2.2		3.3	4.8	4.9	3.6	2.1	3	0.7	1.4	1.5	
Ca	0.1	0.1	0.2	0.2	0.1	1	0.6	1.3	1.3	0.1					0.5	0.1	0.1	0.1	0.1	
Ti	0.5	0.4	0.5	0.4	0.4	0.5	0.5	0.4	0.4	0.5	0.2	0.4	0.4	0.4	0.4	0.5	0.2	0.4	0.4	
Br	1.7									3.8										
S	0.3		0.4		0.5				0.4					0.2		0.5	0.3	0.2		
Cl	0.1		0.1						0.1											
P																	0.2	0.3	0.3	

Table 2: EDX composition analysis (several columns for the same sample means several sites have been analysed)

3.3. XPS spectra

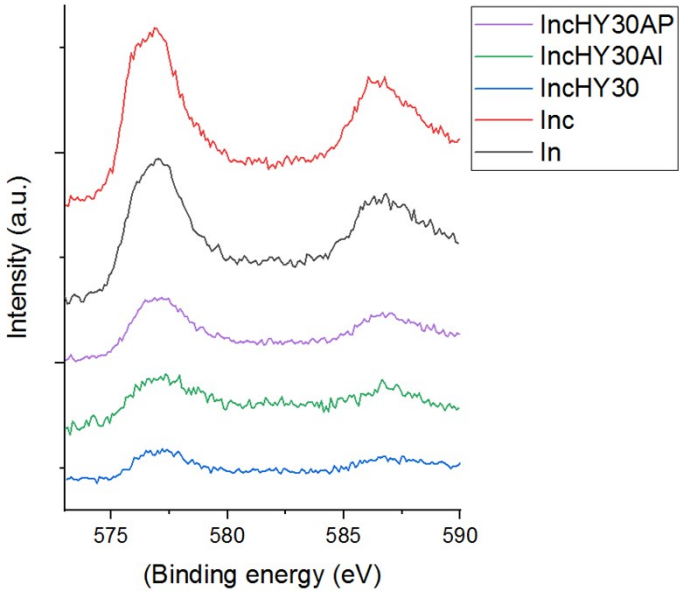

Figure 3: Cr 2p specta of spent catalysts