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CRM GROUP

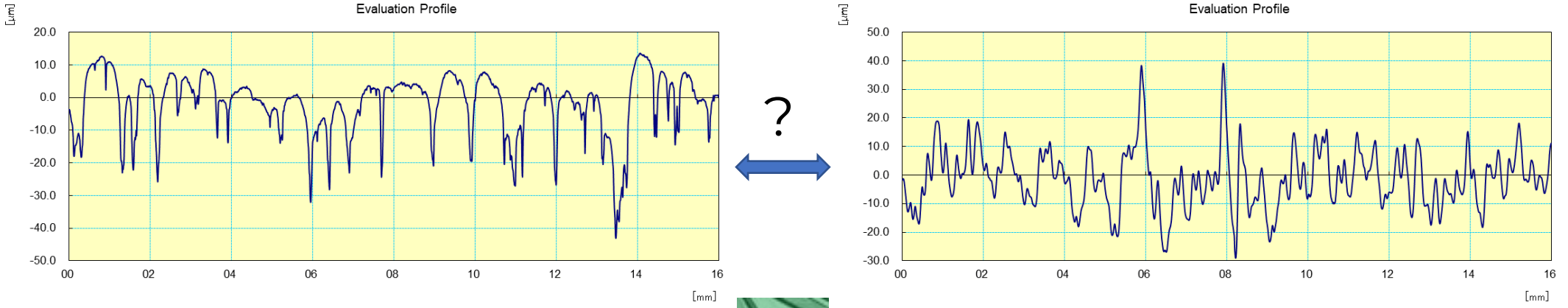
Comparaison des performances intrinsèques de technologies de parachèvement sur pièces imprimées en Ti6Al4V

Comparison of the intrinsic performance of subtractive finishing technologies for printed Ti6Al4V parts.

Context and objectives of this study

- Main selection criteria for choosing a finishing technology:
  - Cost
  - Geometrical compatibility
  - Surface visual quality, + Ra
  - Resulting surface morphology + impact on final application

→ Comparison of the 'intrinsic' performances of finishing techniques, independent of geometrical constraints and for an imposed material removal



Outline

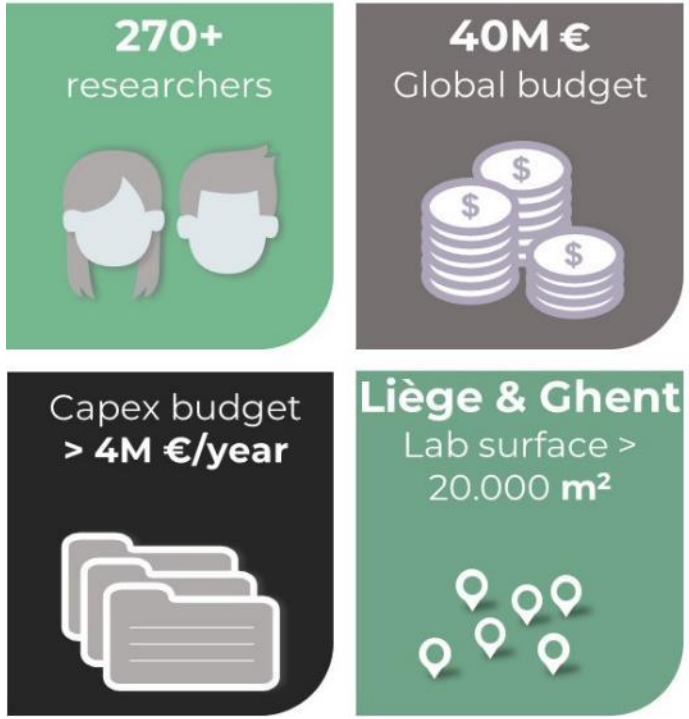
- *Presentation of CRM Group*
- *Methodology*
- *Results*
  - *Surface morphology evolution*
  - *Surface cleanliness*
  - *Shape preservation*
- *Conclusions*

CRM Group

Independent research organization founded in 1948

- **Product – Process - Application** approach
- From lab scale over **pilot lines to industrialization**
- **Multi-sectorial** approach – **cross-pollination**

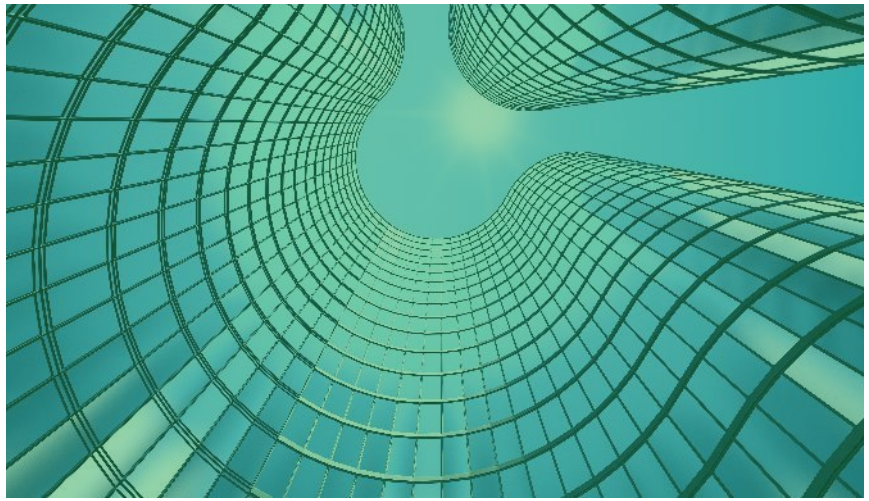
45 members & 350+ clients / year

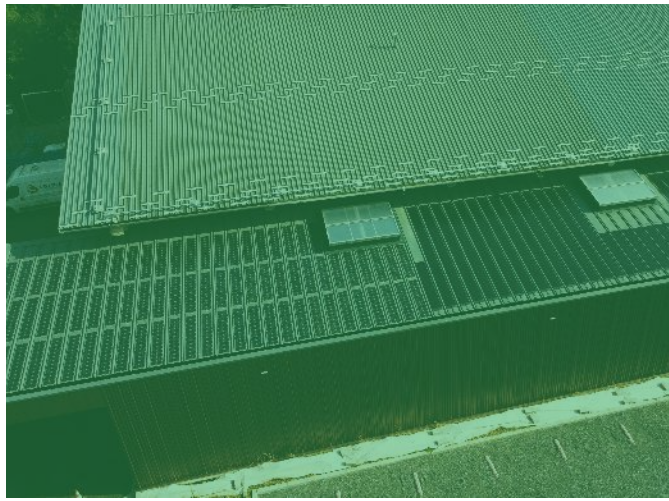


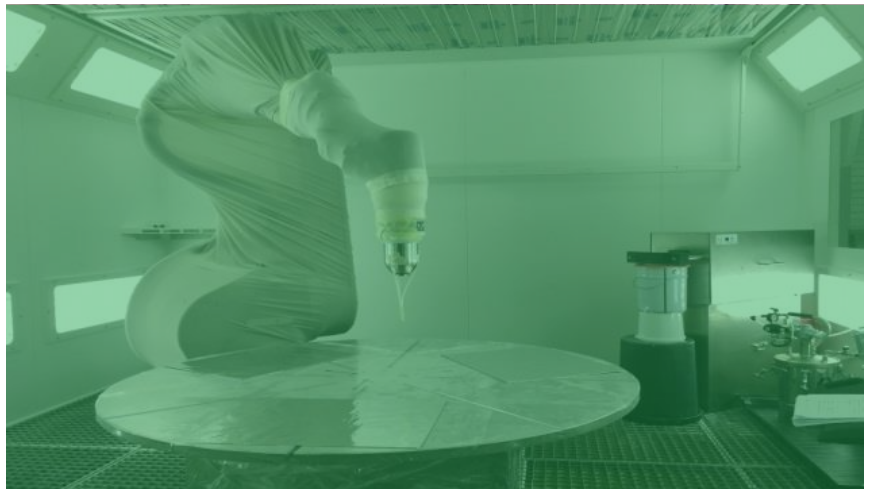
Our development axes

Vision & innovation with industrial solutions

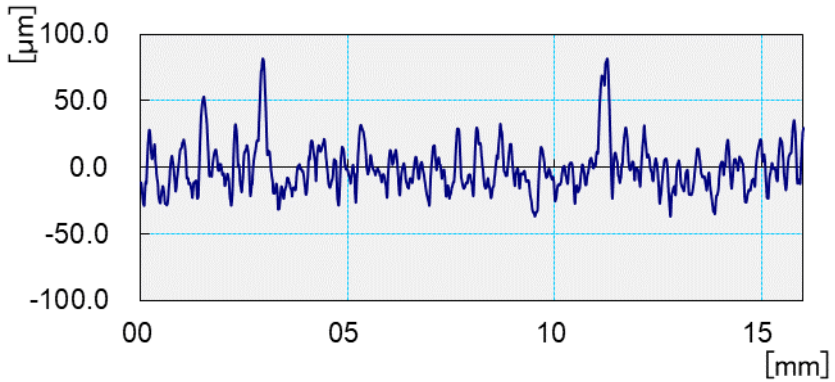
- **PROCESS – PRODUCT – APPLICATION DEVELOPMENT**
- **ENERGY SHIFT**
- **ADVANCED MANUFACTURING**
- **INDUSTRY 4.0 & DIGITALISATION**
- **CIRCULAR ECONOMY**
- **CONSTRUCTION**

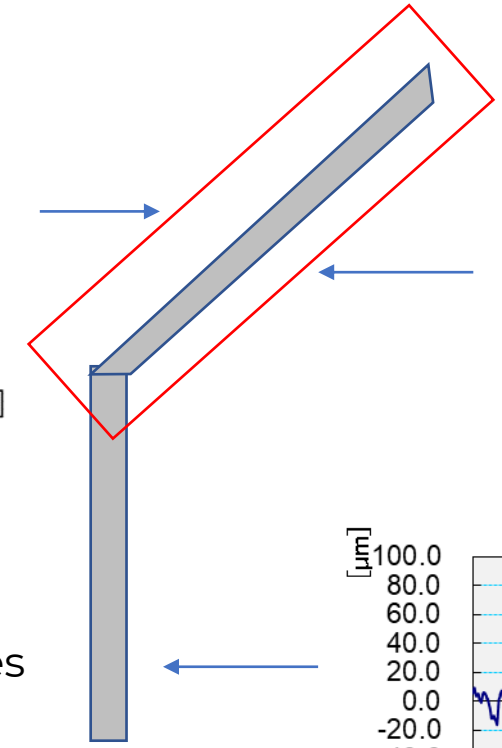


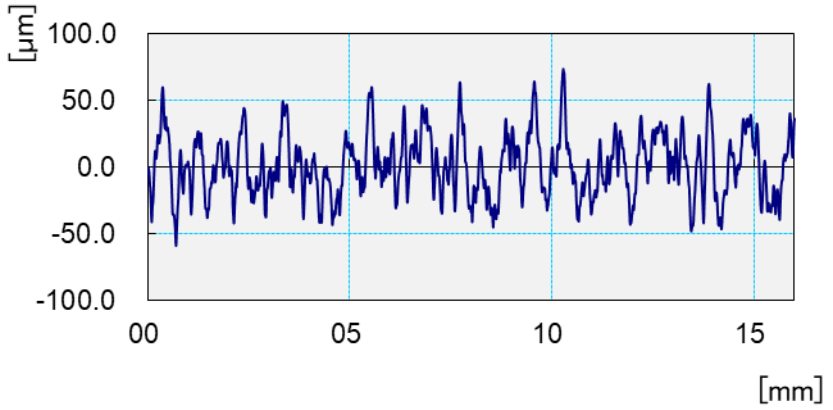


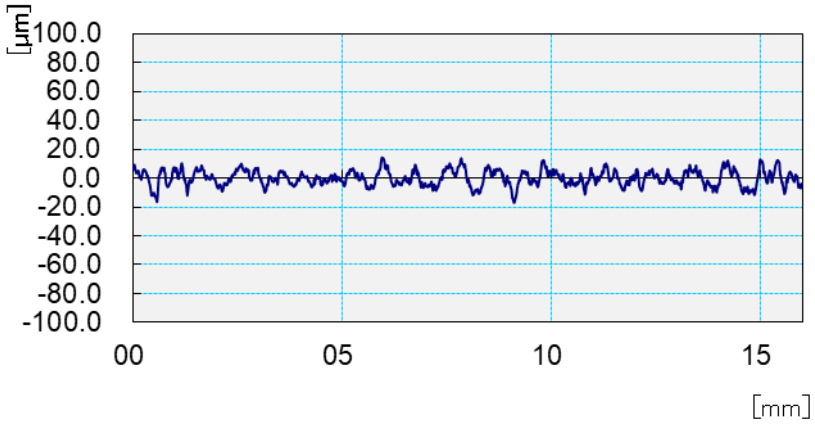


Characterisation of ‘as-printed’ condition





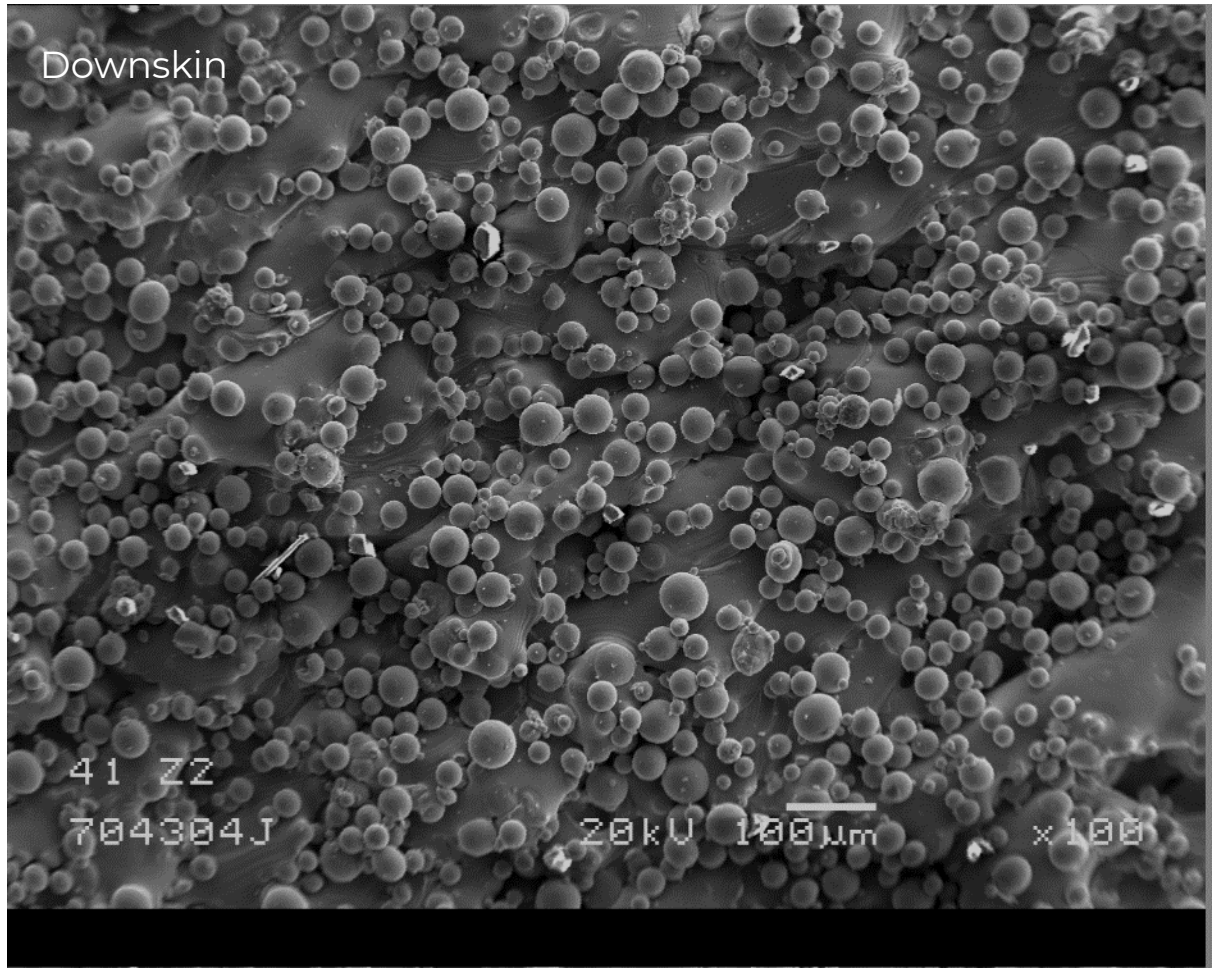


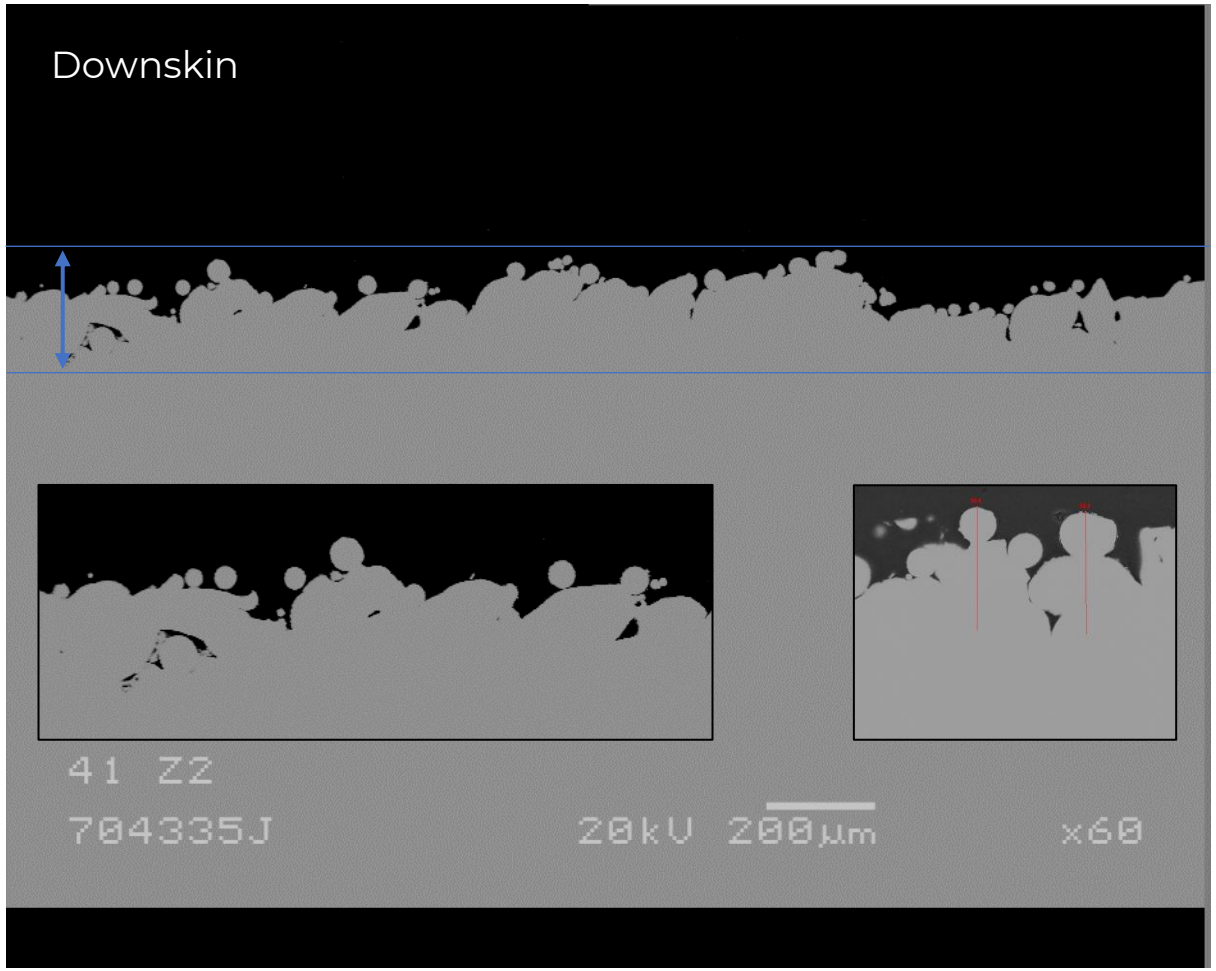


- Material : SLM TI6Al4V
- Selection of unsupported 45°-printed samples for the study (worst surface condition)
- Comparison of upskin and downskin faces
- 2 printing conditions (40 and 80µm layers)

Characterisation of ‘as-printed’ samples

unsupported 45° printing, 40µm layers





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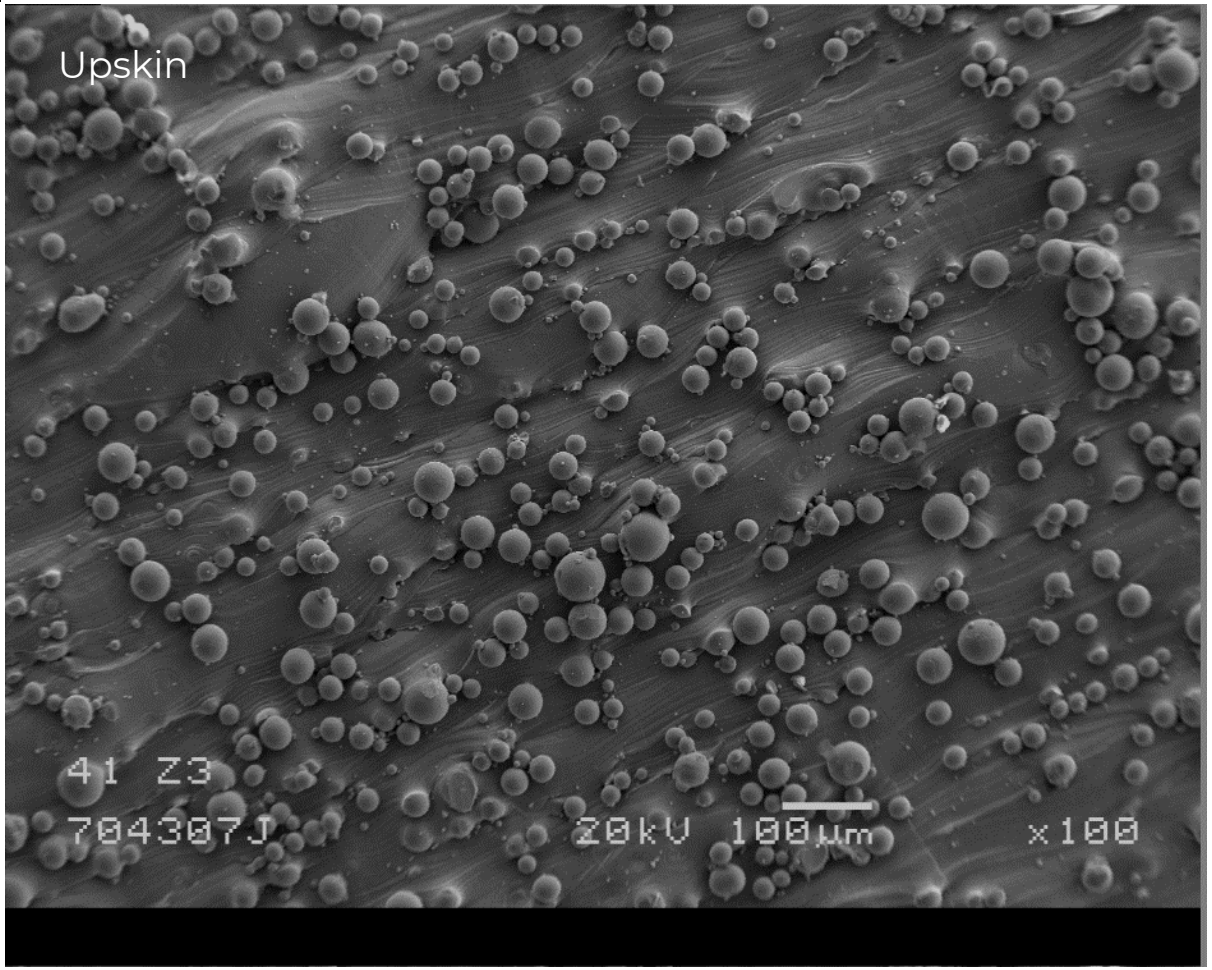
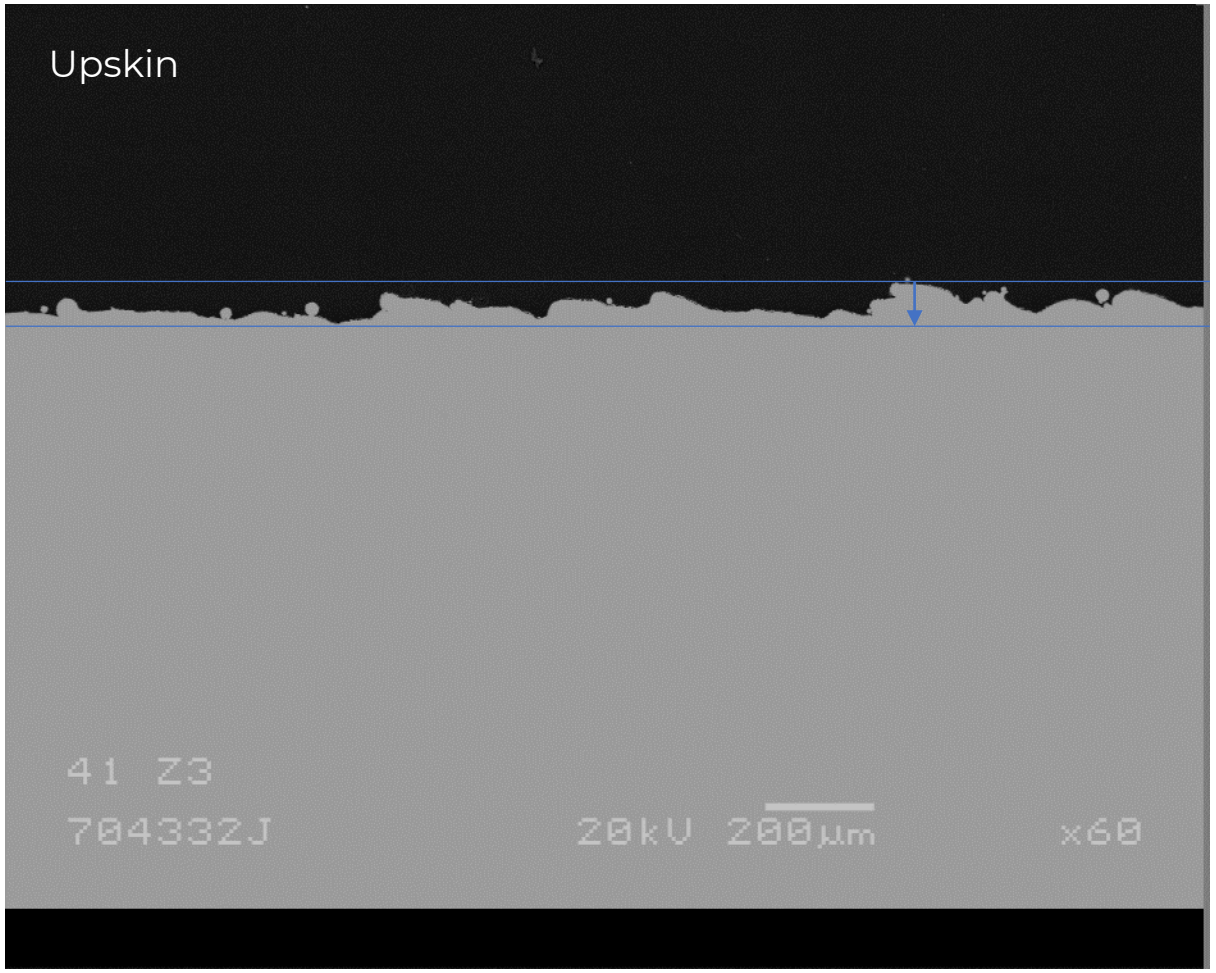
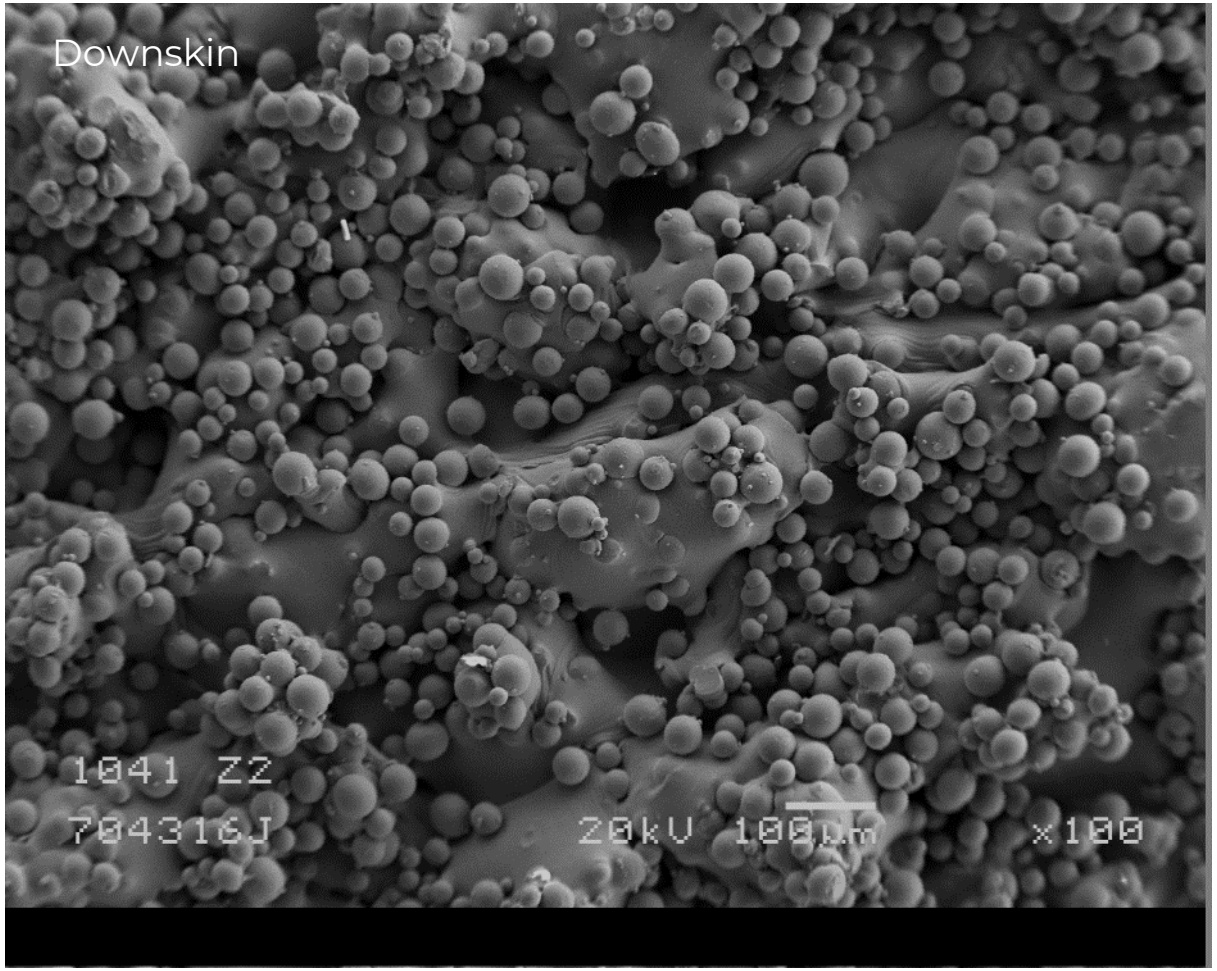
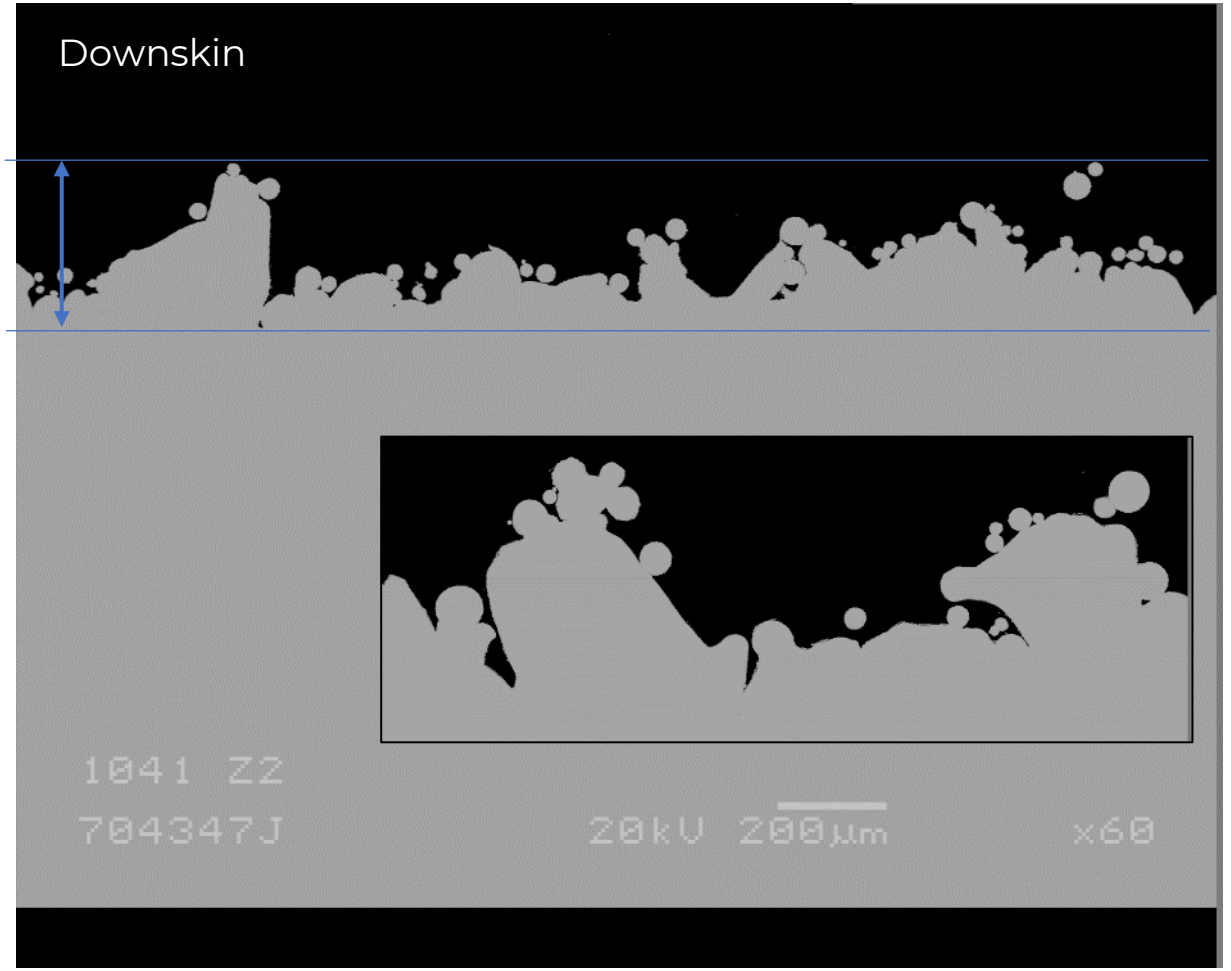




Characterisation of ‘as-printed’ samples

unsupported 45° printing, 80µm layers





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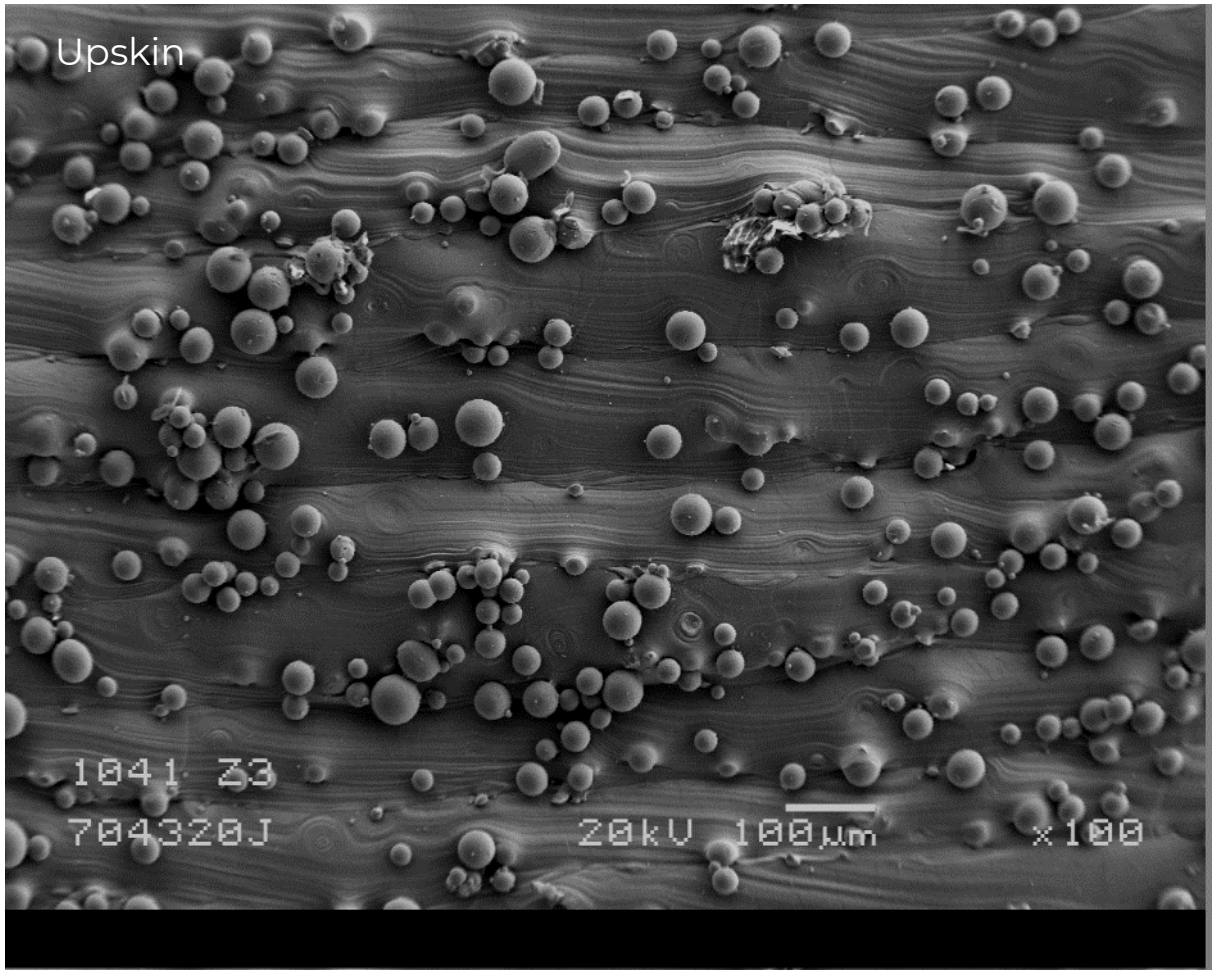

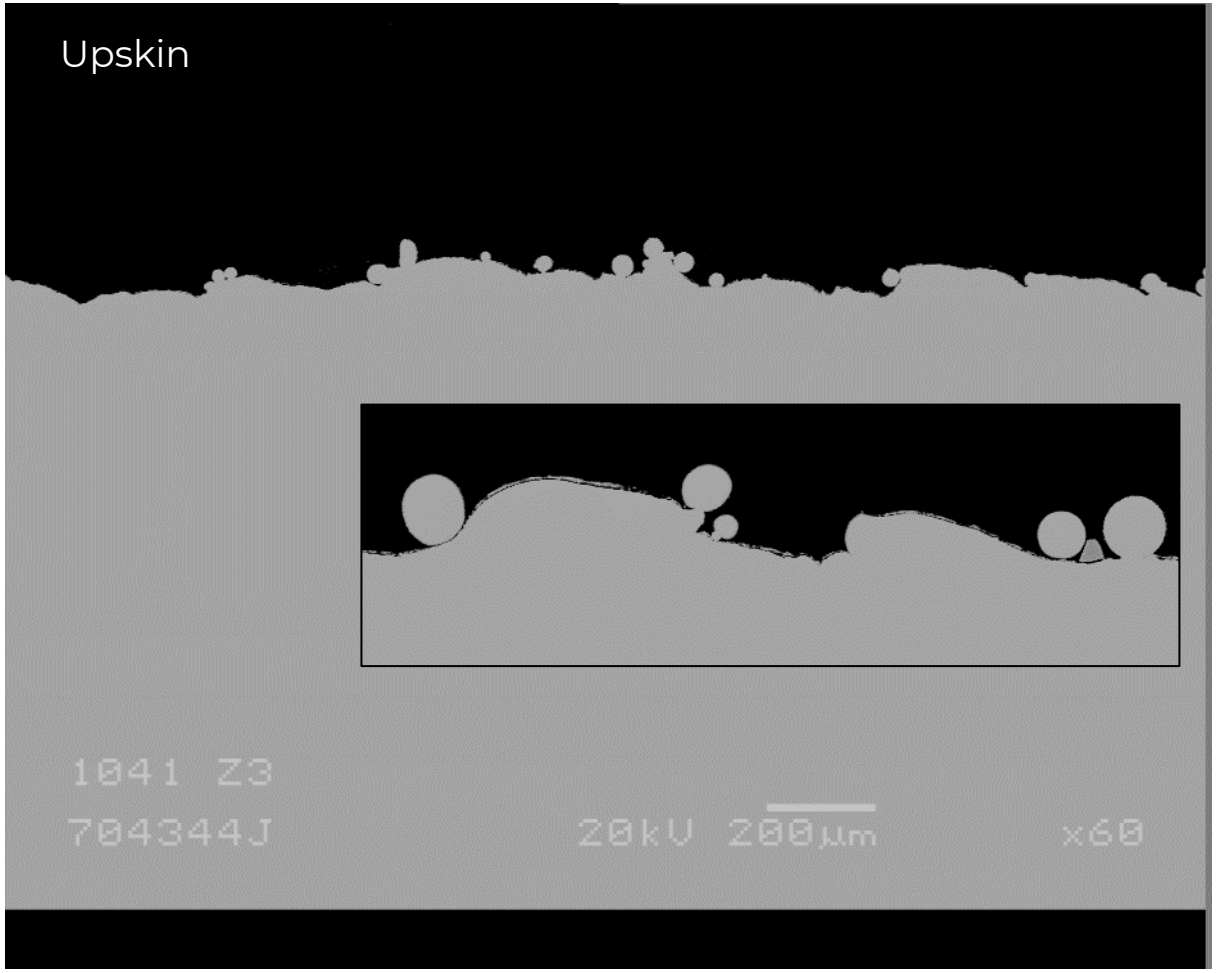

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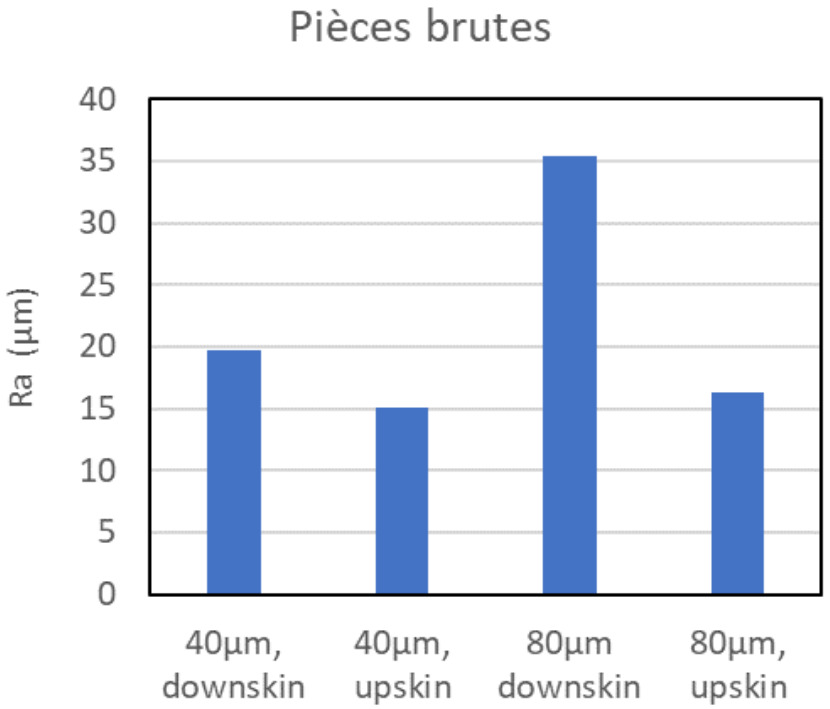
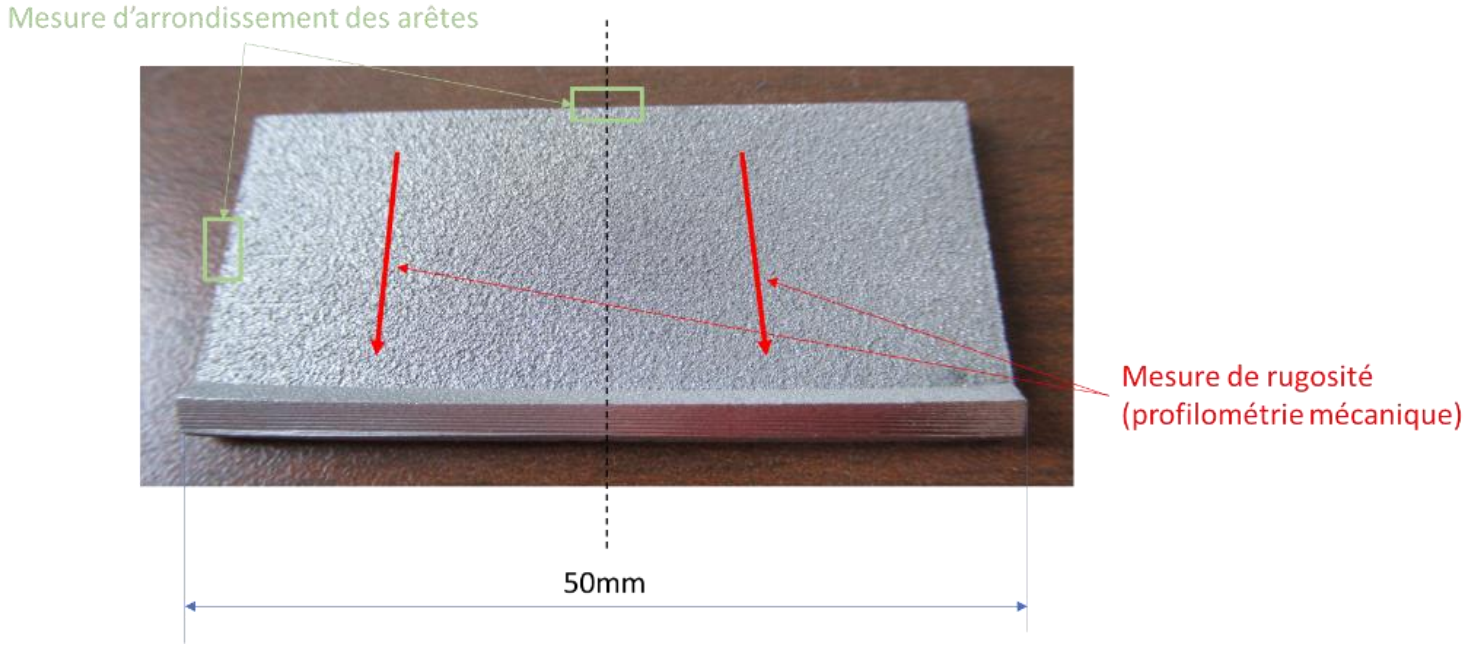




- Initial surface condition characterized by an Ra of 20µm and 35µm for the two printing conditions
- Printing layer thickness has little impact on the roughness of upskin faces

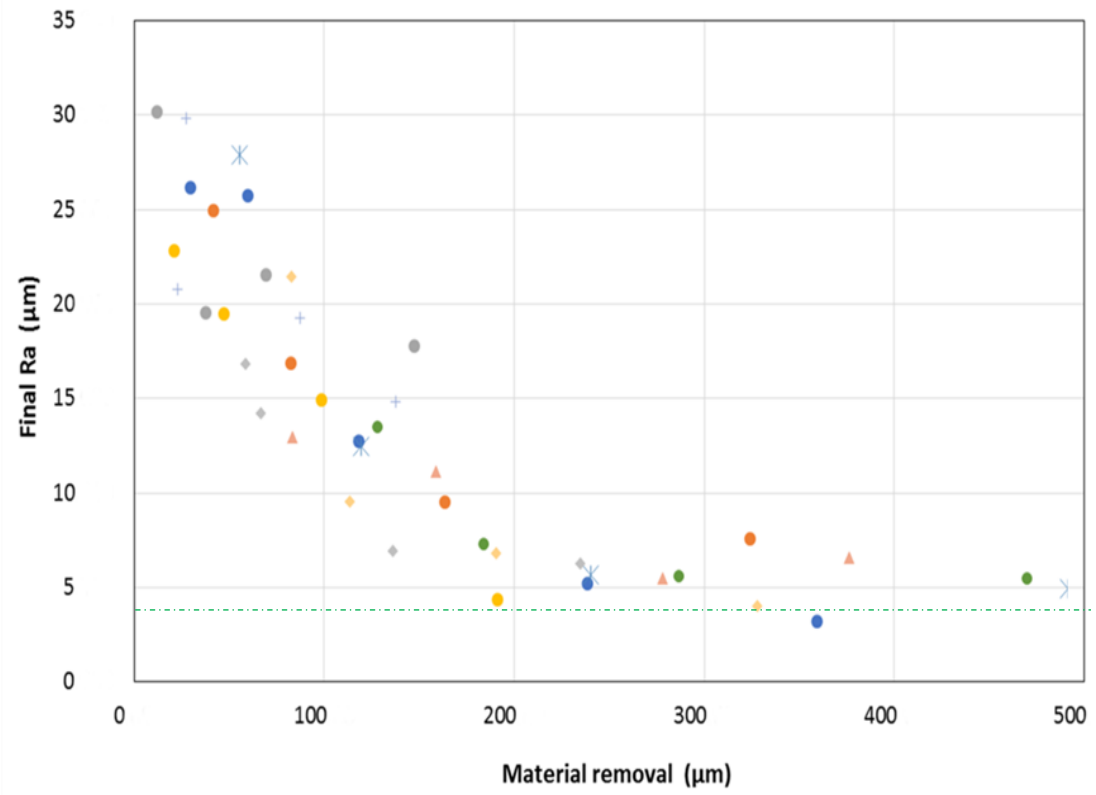
Benchmarking of finishing technologies

Polissage chimique	
Sample	Target mass loss (g)
114	0.3
115	0.6
116	0.9
117	1.2
118	1.7
119	2.3
120	For calibration pre-trials
121	For calibration pre-trials
1114	0.3
1115	0.6
1116	0.9
1117	1.2
1118	1.7
1119	2.3
1120	For calibration pre-trials
1121	For calibration pre-trials

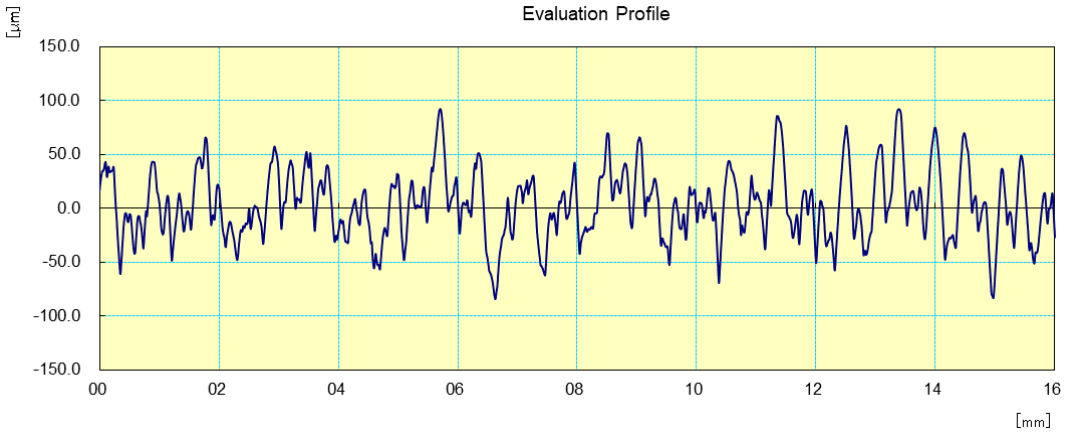
- Selection of 6 finishing technologies
- Subcontracting of the finishing to 'experts'
- Imposition of mass loss targets in the range of 0.3-2.3g for chemical techniques (i.e. 25-200µm) and up to 1.1g (i.e. 100µm) for mechanical ones

- Chemical polishing (3 suppliers)
- Electropolishing (2 suppliers)
- Dry electropolishing (Dlyte®)
- Sand-blasting
- Tribofinishing
- MMP®

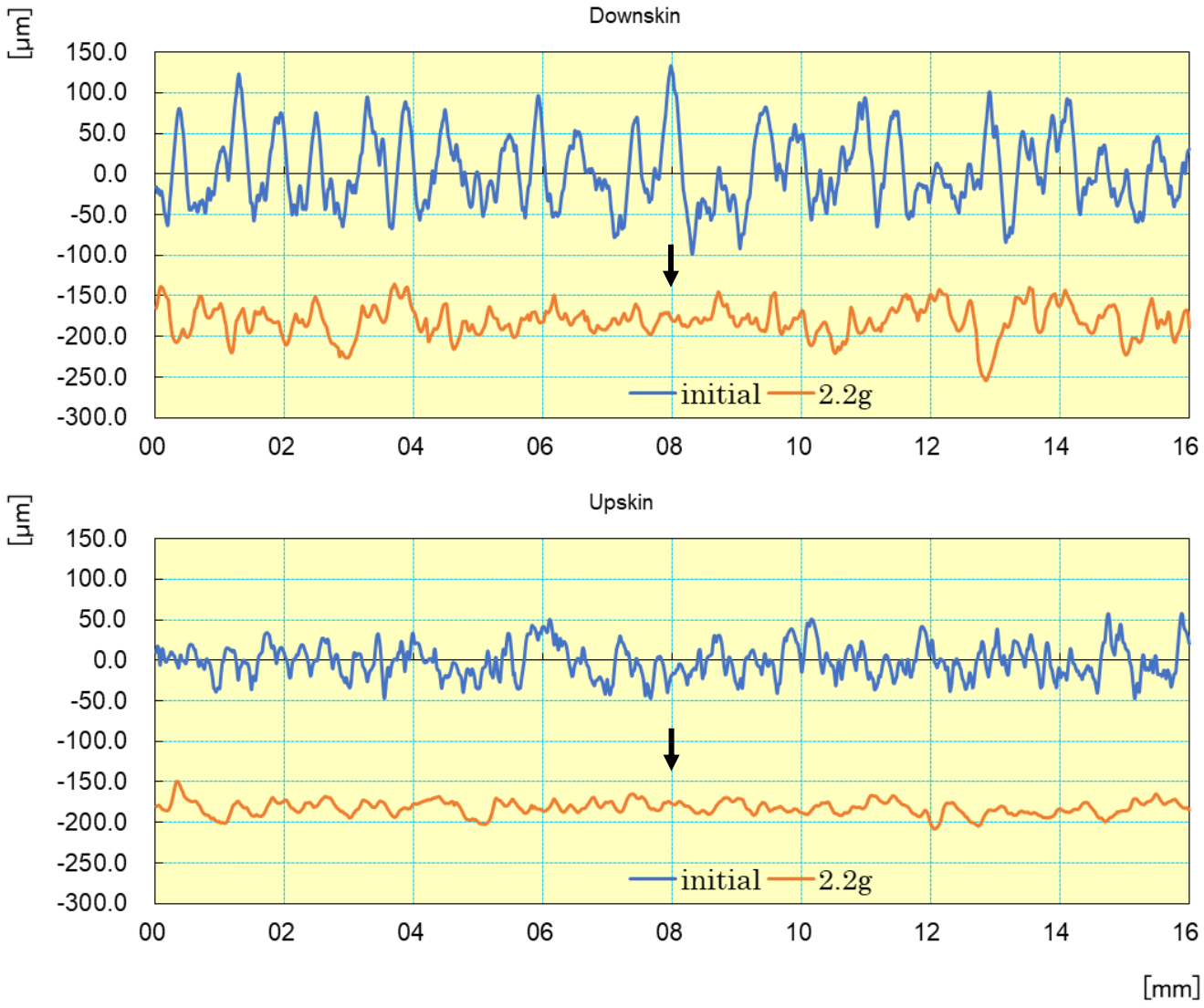
Goals and methodology of this study

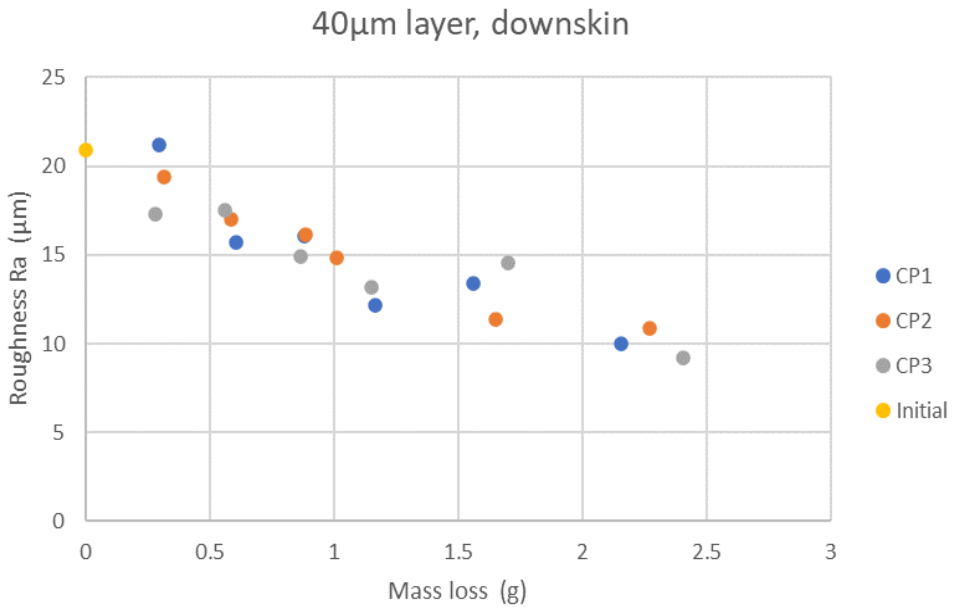


- Post-finishing characterisations
  - Roughness-mass loss reference curves
  - Characterisation of surface morphology
  - Removal of solid contaminants
  - Maximum material removal
  - Shape preservation



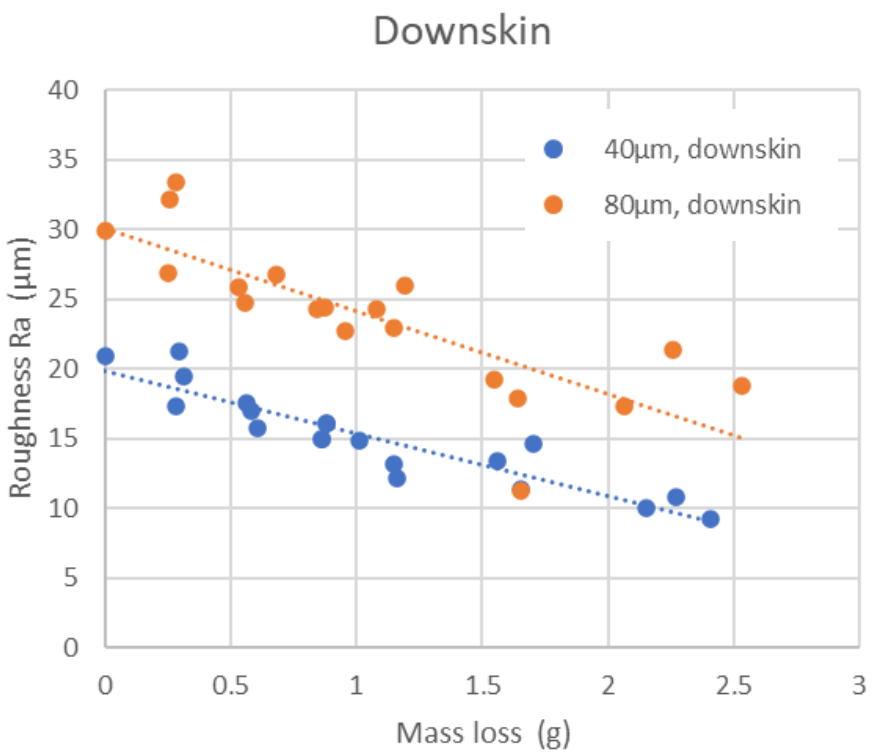
Chemical polishing

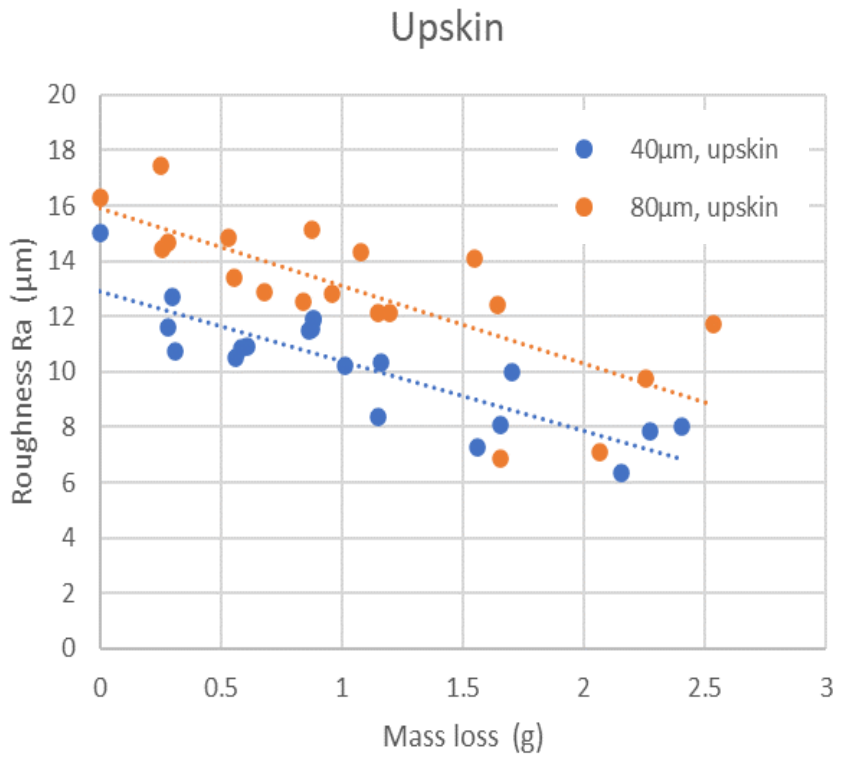




- Large material removal easy to achieve
- Significant residual roughness even after removal of ~200µm
- Similar trends achieved by all subcontractors

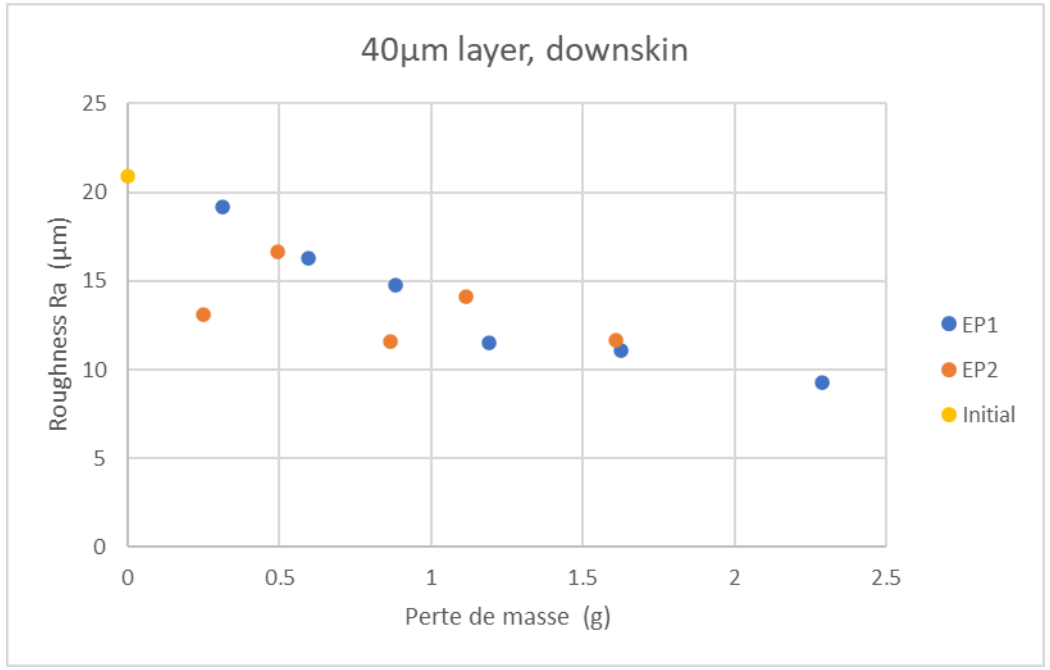
Chemical polishing

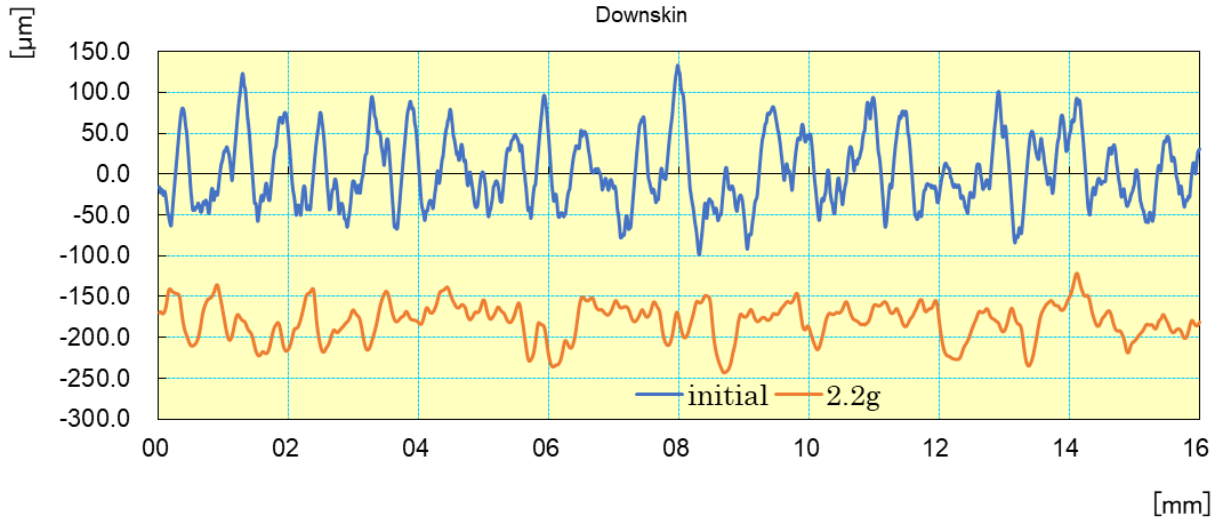


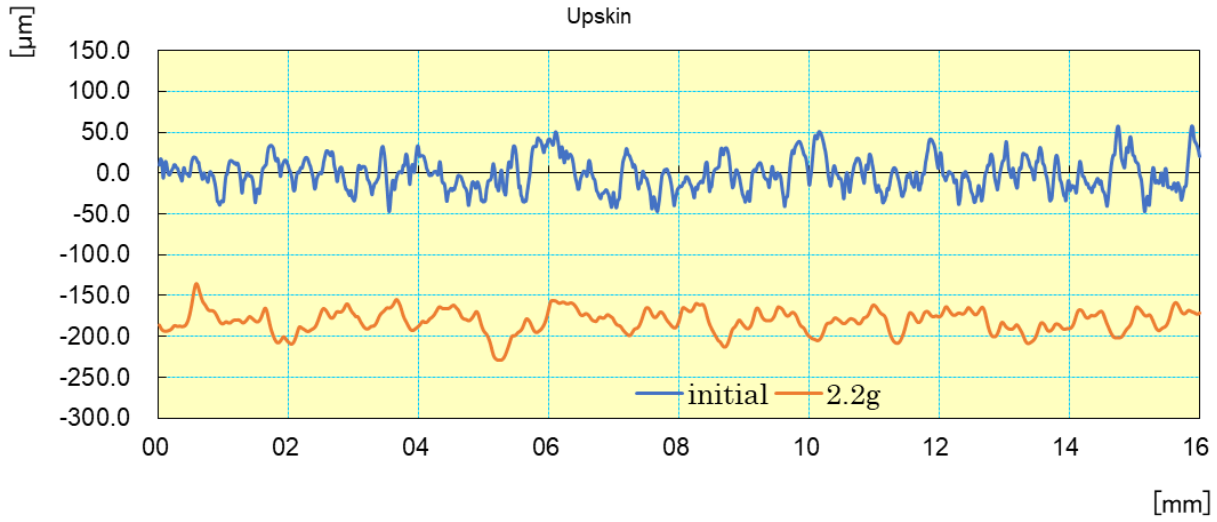


- General trend for both upskin and downskin surfaces : Ra divided by 2 after removal of 2.5g (~200µm)
- Linear trend, with wide data scattering though

Electropolishing

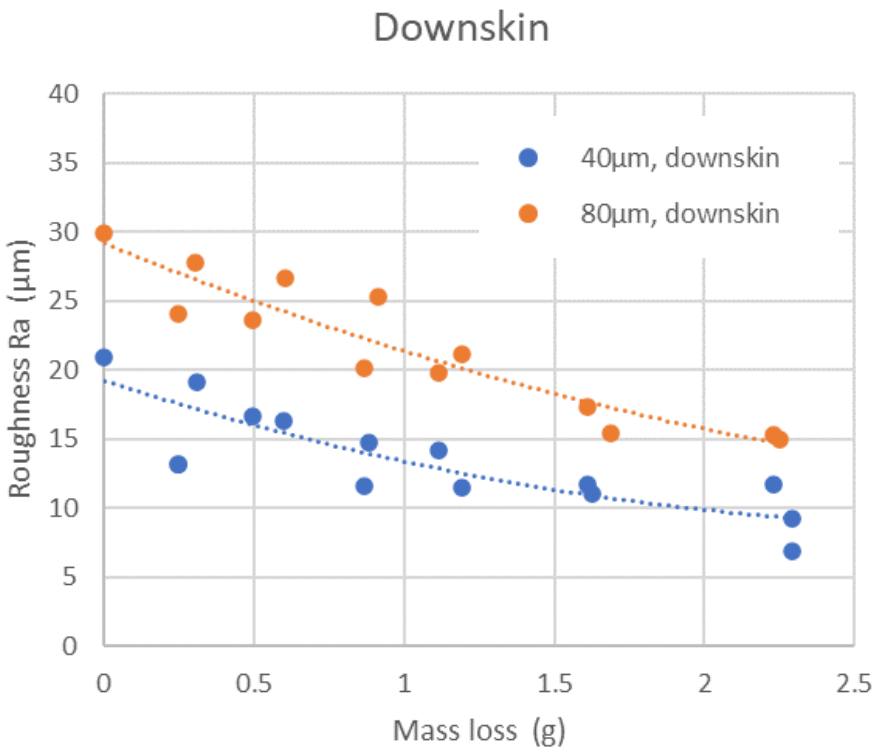


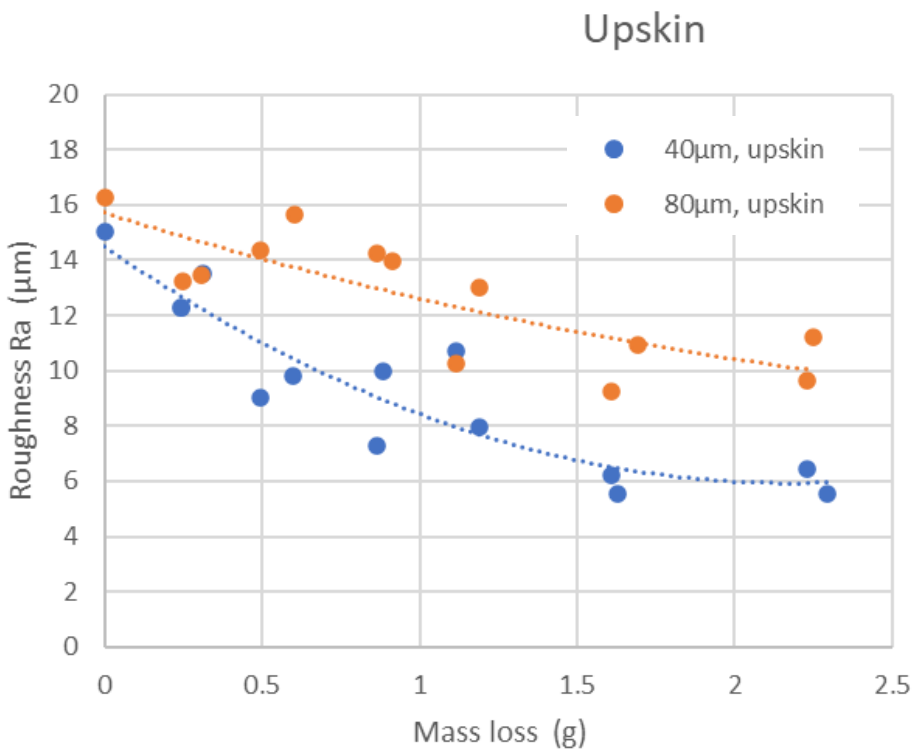




- Large material removal easy to achieve
- Significant residual roughness (waviness) even after removal of ~200µm
- Surface morphology very similar to chemical polishing
- Similar trends achieved by the 2 contractors

Electropolishing



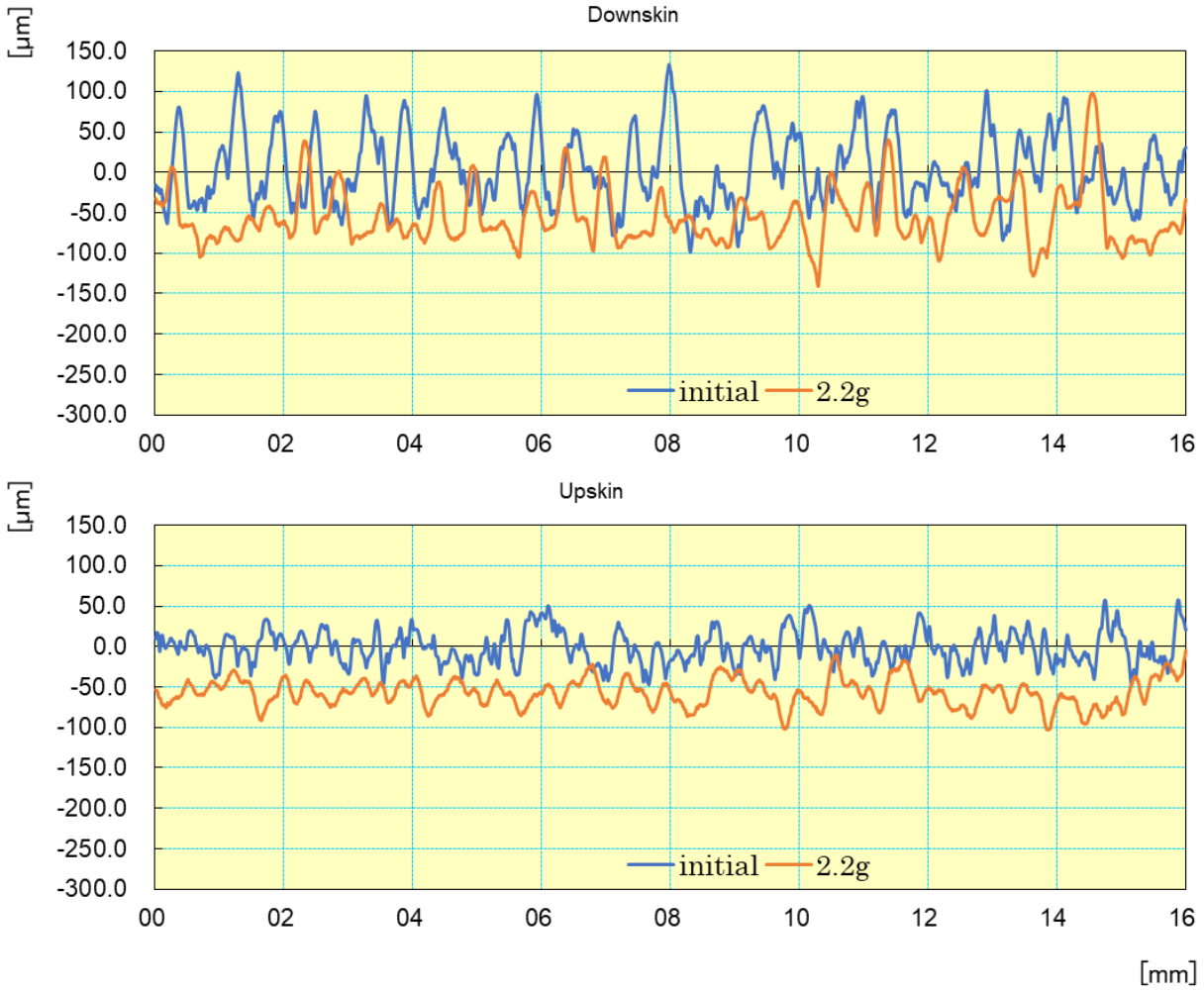


- Final roughness after removal of 2.3g in the same range as for chemical polishing (slightly better)
- Wide data scattering

Dry-blasting

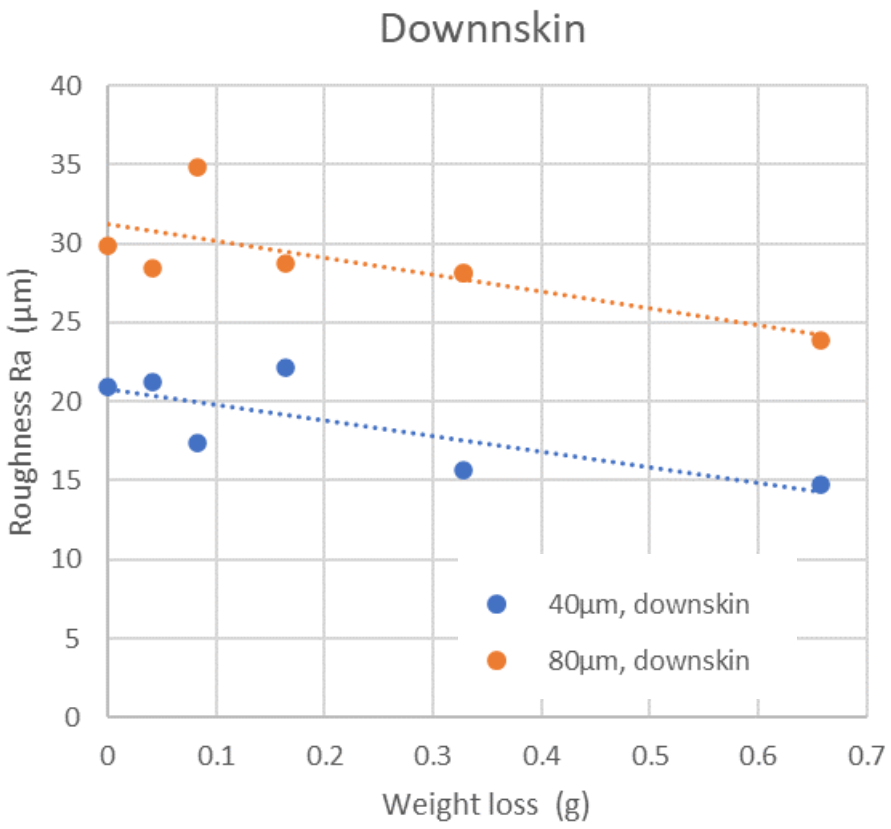
Medium : 250µm alumina (corindon) particles

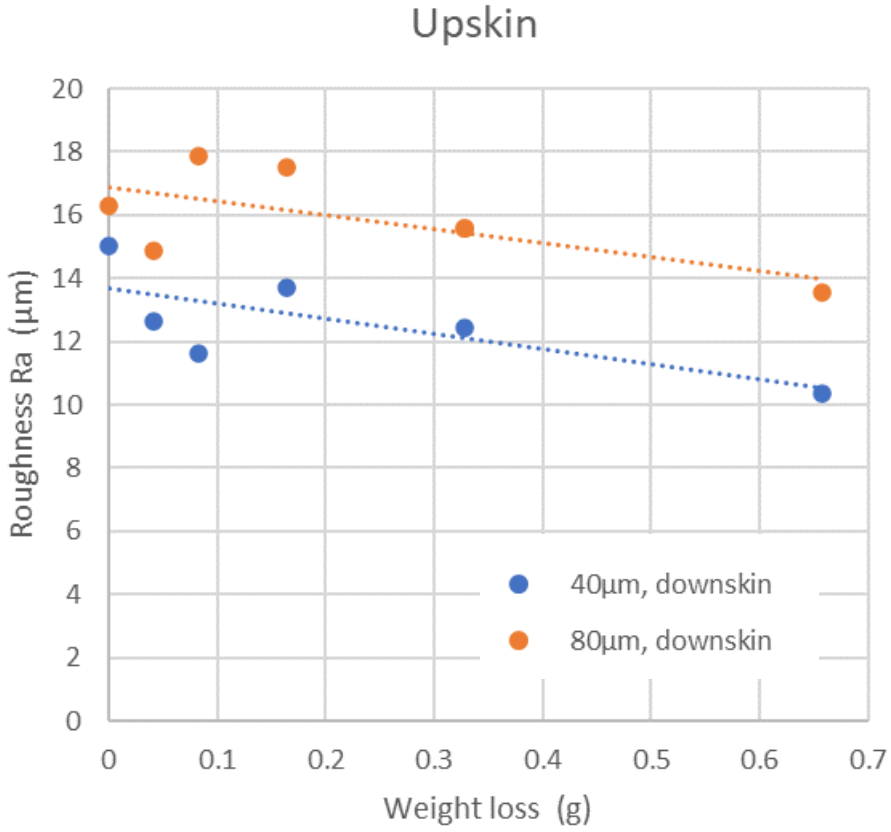
Pressure : 3 bar



- Material removal limited by the patience of the operator (in the case of manual blasting)
- Significant residual roughness, in the same range as with chemical polishing

Dry-blasting

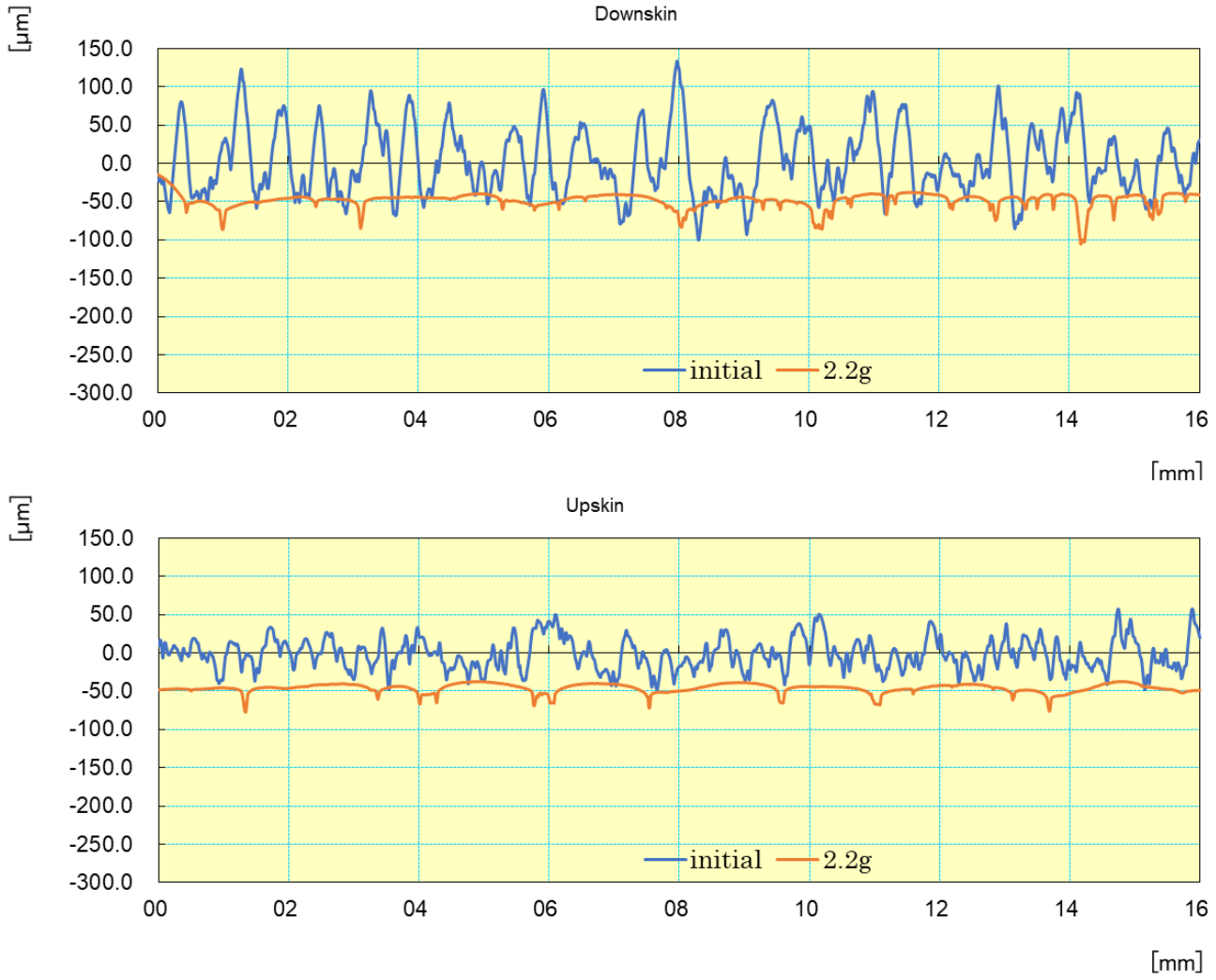




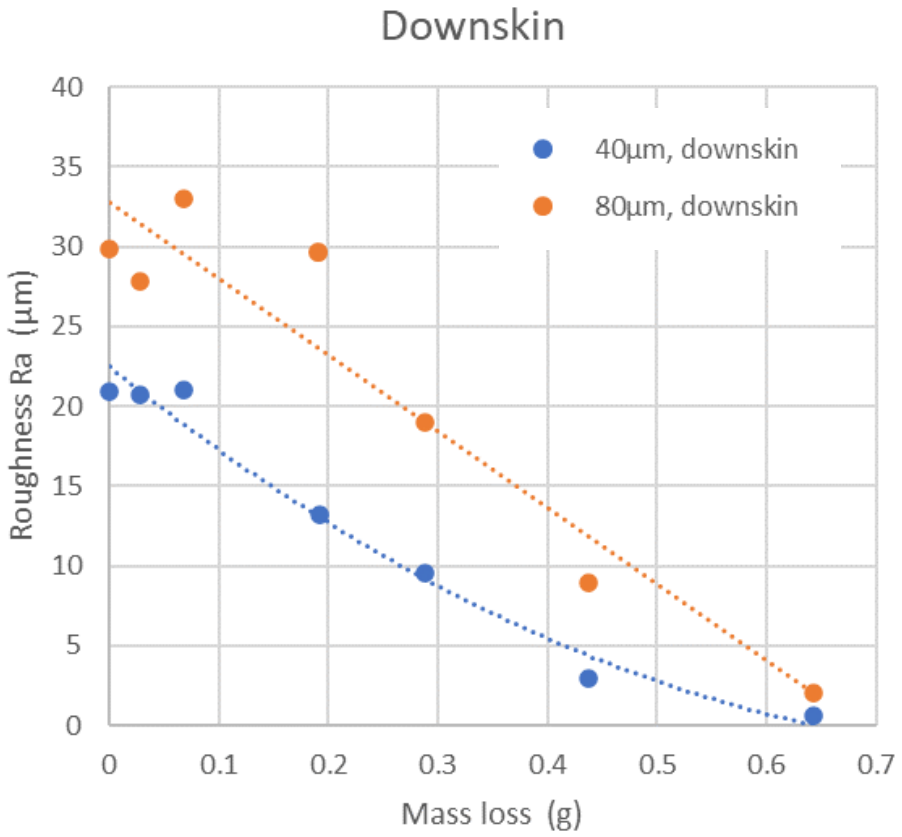
- General trend for both upskin and downskin surfaces : Ra decreased by 25% after removal of 0.5g (~50µm)
- Linear trend, with wide data scattering

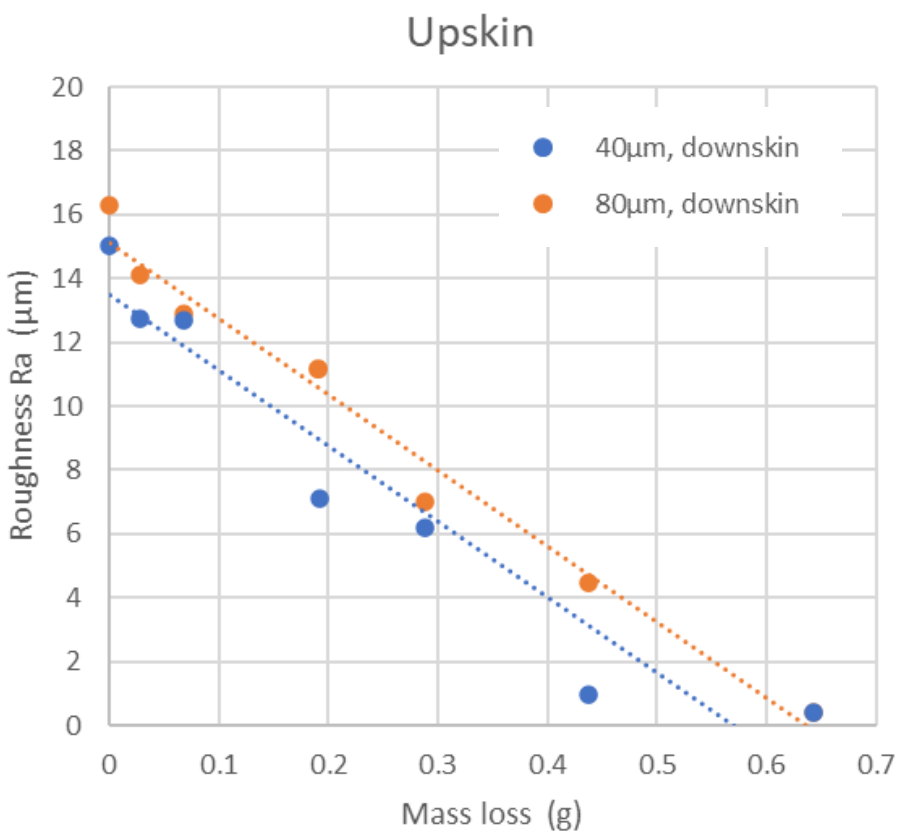
Tribofinishing

- Material removal limited in practice by the alteration of the shape (preferential erosion of sharp edges)
- Very efficient removal of waviness → flattening of the surface



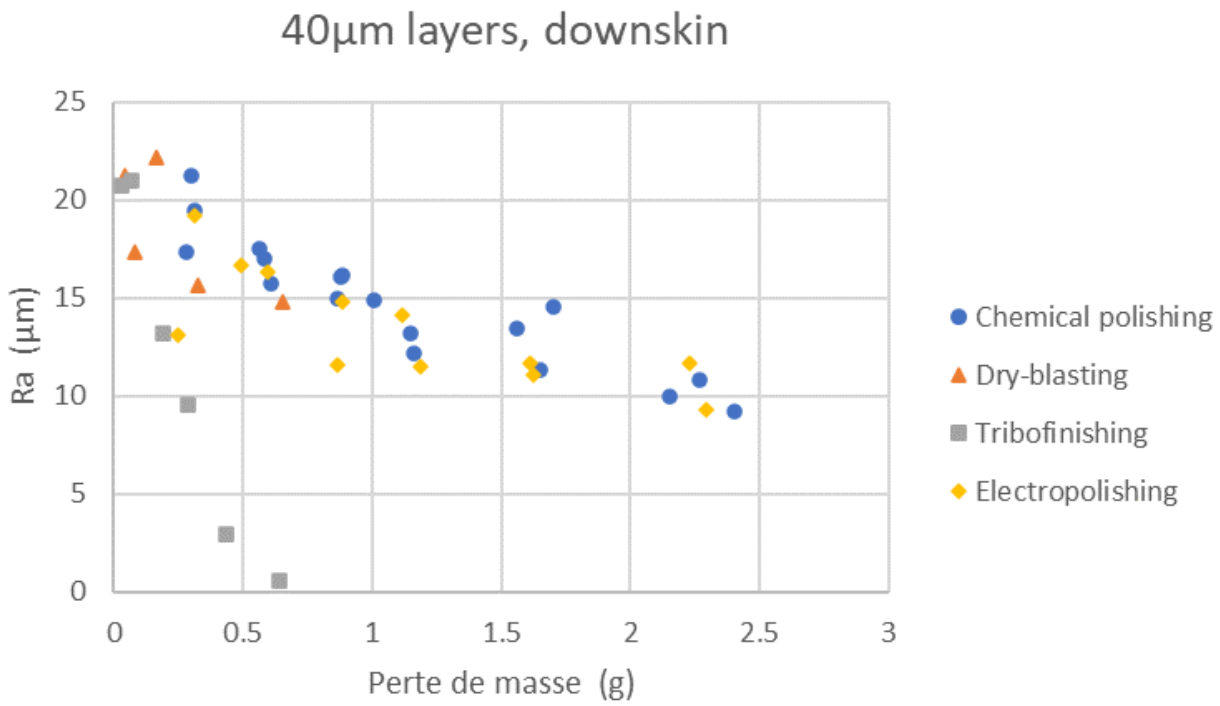
Tribofinishing

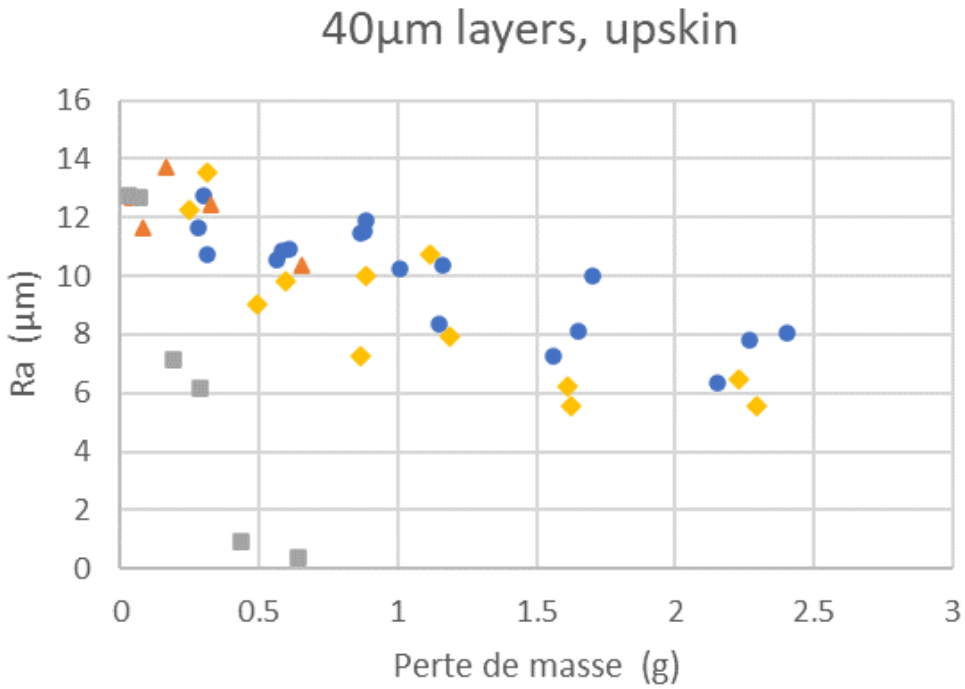




- In contrast to the previous 3 techniques, the Ra drops to values below 1µm for both upskin and downskin orientations

Benchmarking : synthesis

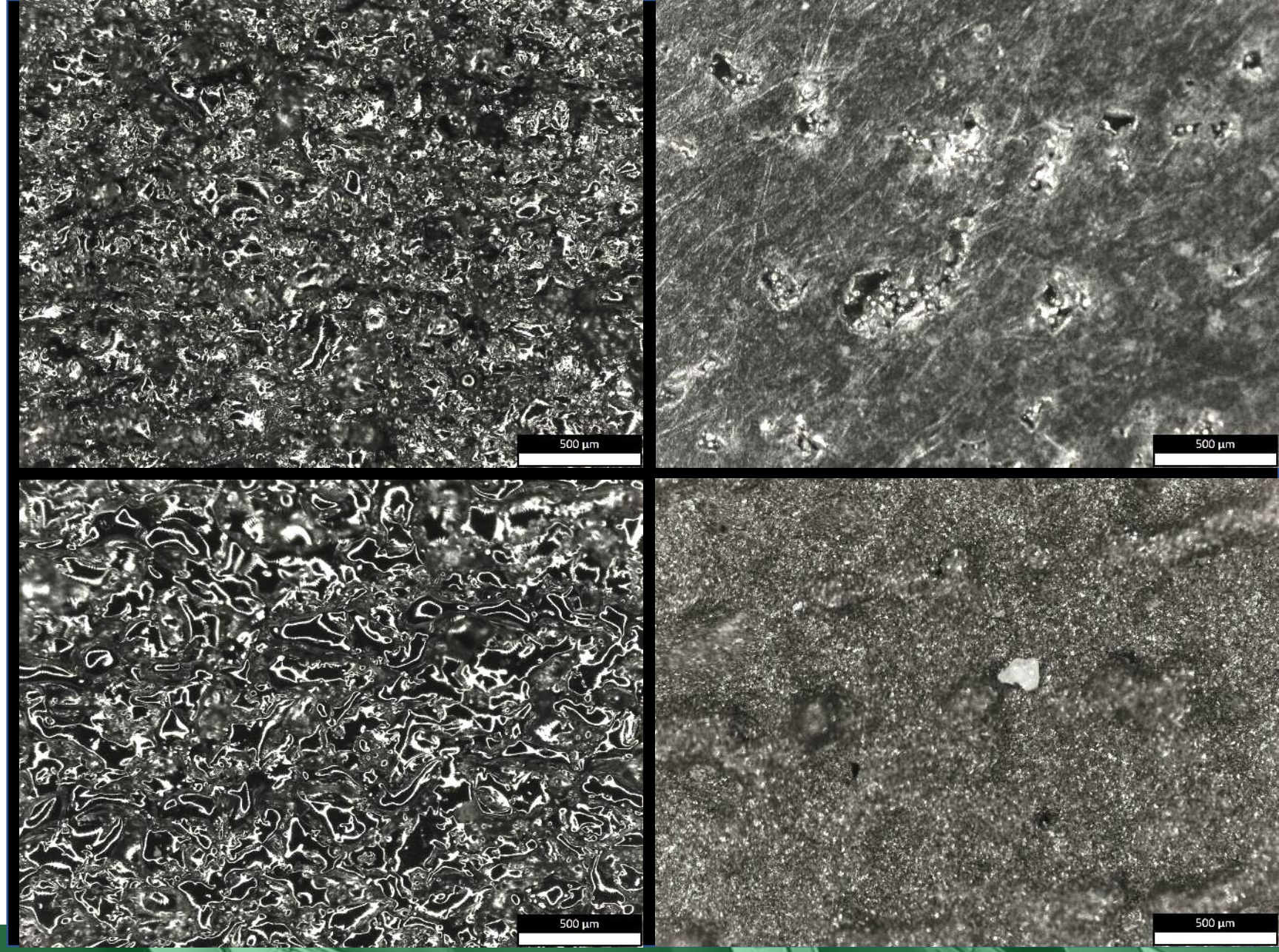




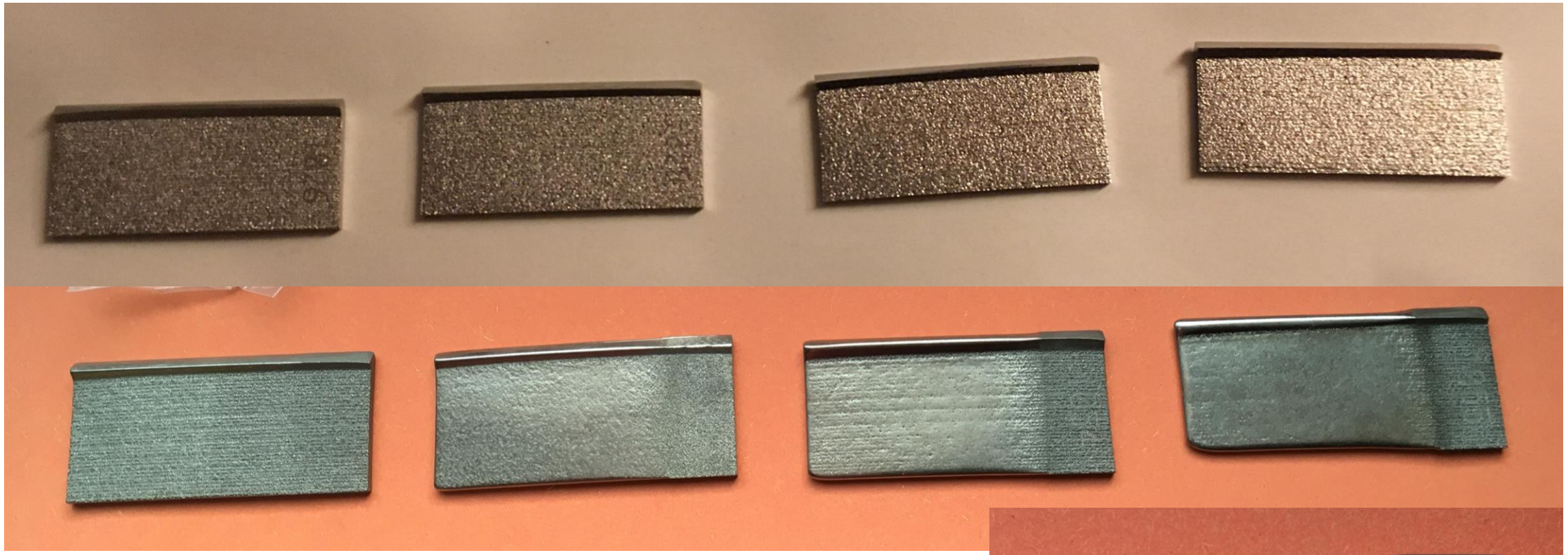
- Very similar trends observed for chemical polishing, electropolishing and dry blasting
- Tribofinishing is much more effective for decreasing the roughness

Cleanliness

- Even in the case of small mass losses, chemical polishing and electropolishing yield surfaces free of solid contaminants
- Powders still present in the recesses of the surface in the case of tribofinishing, even for Ra <1µm
- Blasted surfaces are virtually free of metallic powders but some alumina particles are observed (not much)



Shape alteration



- Slight edge rounding observed with electropolishing
- Large deviation of shape (millimetric) for long tribofinishing times

Conclusions

	Material removal		Smoothness		Cleanliness		Shape preservation
	high	lowest	macro	nano	Solid particles	Cleaning ability	homogeneity
Chemical polishing	++	-	+	-	++	-	+++
Electropolishing	++	-	+	+++	++	-	-
Dry-blasting	-	+	-	--	-	-	++
Tribofinishing	-	+++	+++	+	--	++	--

- Each finishing technology has assets and drawbacks and yields a characteristic surface morphology
- The compatibility of the surface morphology with the final application needs to be taken into account for the selection of a finishing technique.

Wallonie

Service public de Wallonie

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