An Aluminium-Based Hybrid Material for Laser Multiphoton Polymerisation

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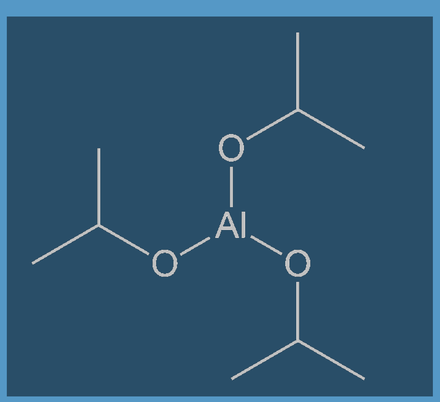
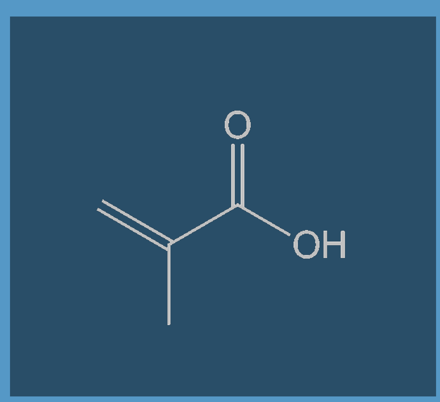
Introduction

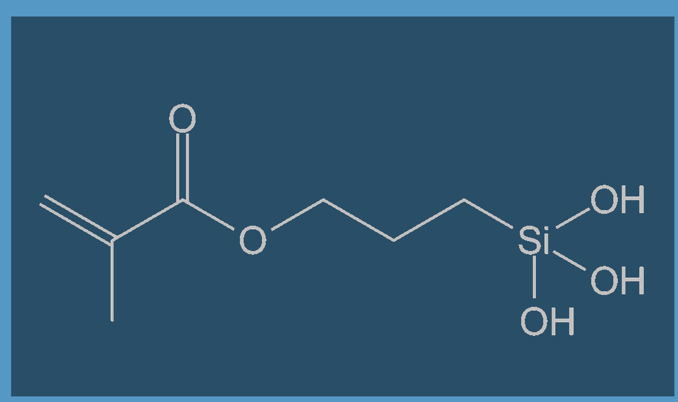
Laser multiphoton polymerisation is a 3D printing technique for producing sub-micrometer objects with unprecedented precision and reproducibility. The technique opens possibilities to tailor scaffolds for tissue engineering [1], photonics elements [2], microfluidics [3] and other structures directly from CAD software. The chemical and physical properties of the printed materials play a key role in their functionality, which motivates the generation of materials with diverse and tunable properties. Here, we present an aluminium-based hybrid organic-inorganic material that is relatively simple to prepare, tune and structure in 3D.

Material Synthesis

The aluminium-based hybrid was prepared by dissolving aluminium isopropoxide (AIP) in toluene and subsequently adding methacrylic acid (MAA) and HCl-hydrolysed 3-methacryloxypropyltrimethoxysilane (MAPTMS) and a photoinitiator (4,4′-bis(diethylamino)benzophenone). After drop-casting on a glass slide, toluene was evaporated and structures were fabricated using a Nanoscribe laser multiphoton polymerisation system.

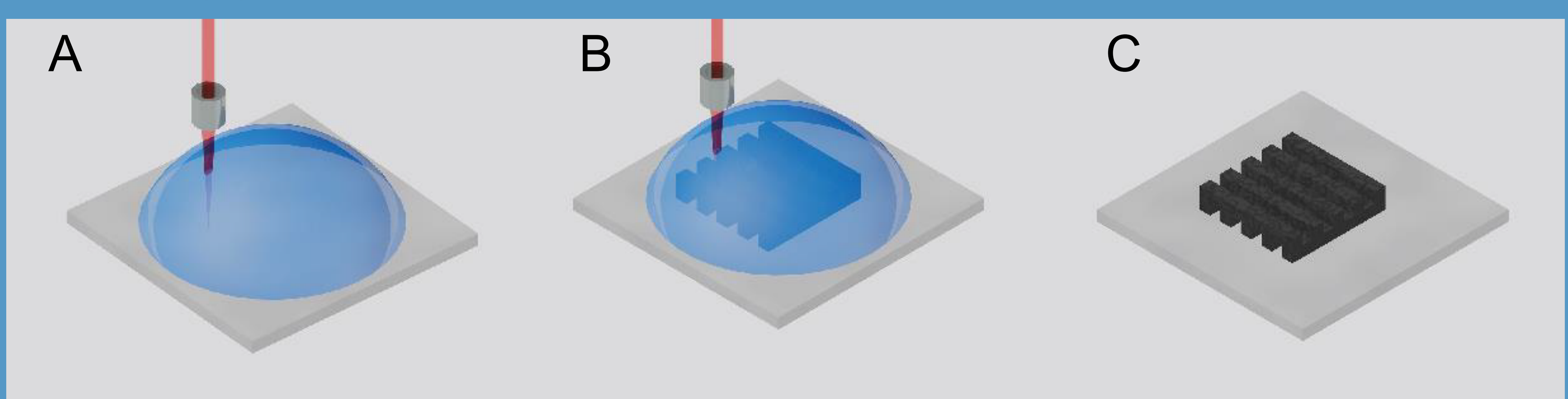




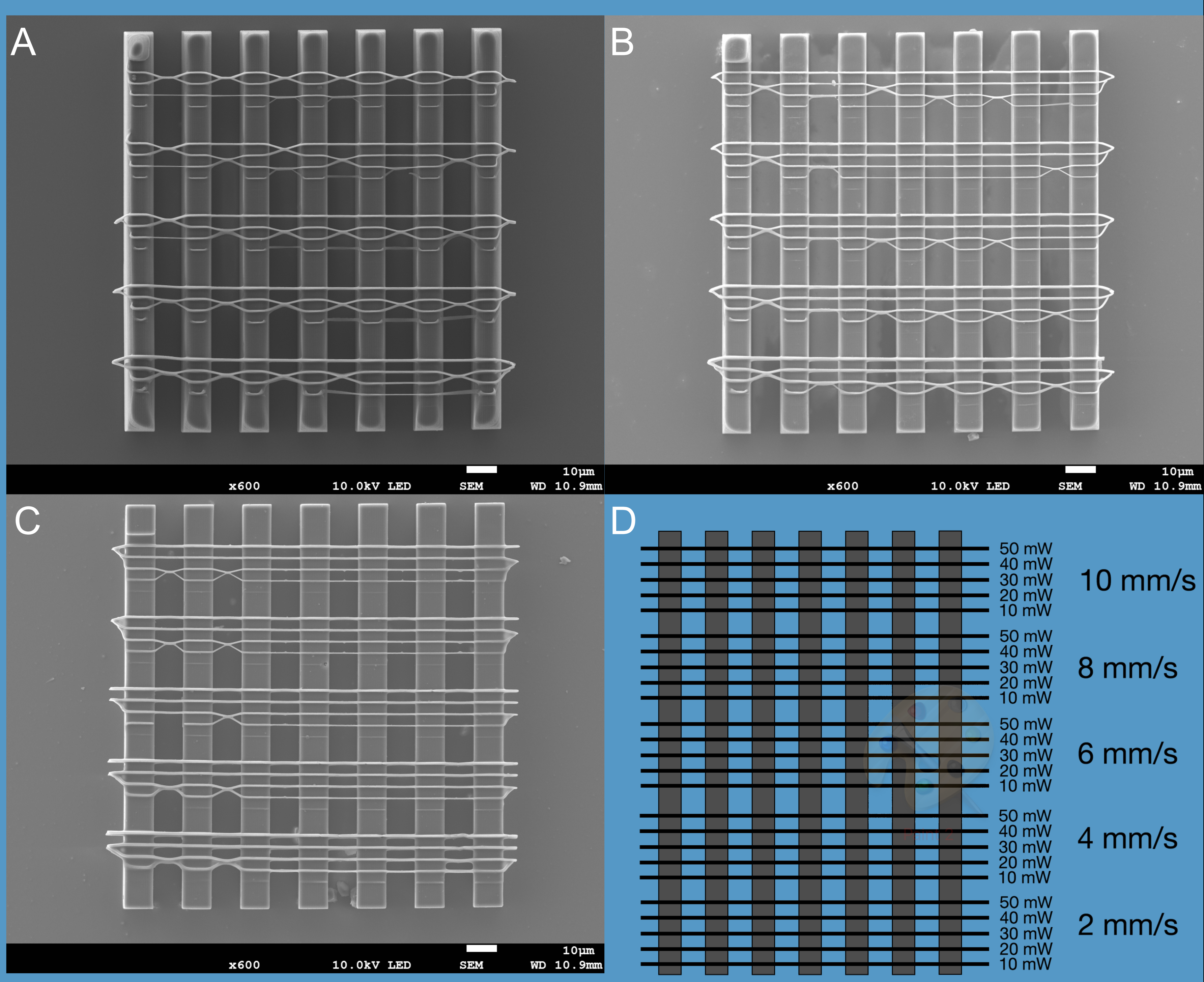


Structure fabrication

A femtosecond laser beam is focused in the material (A). The beam is moved by galvo mirrors according to CAD sketches (B). When the structure is complete, unexposed parts of the material are washed out using a solvent and a free-standing structure is acquired (C).

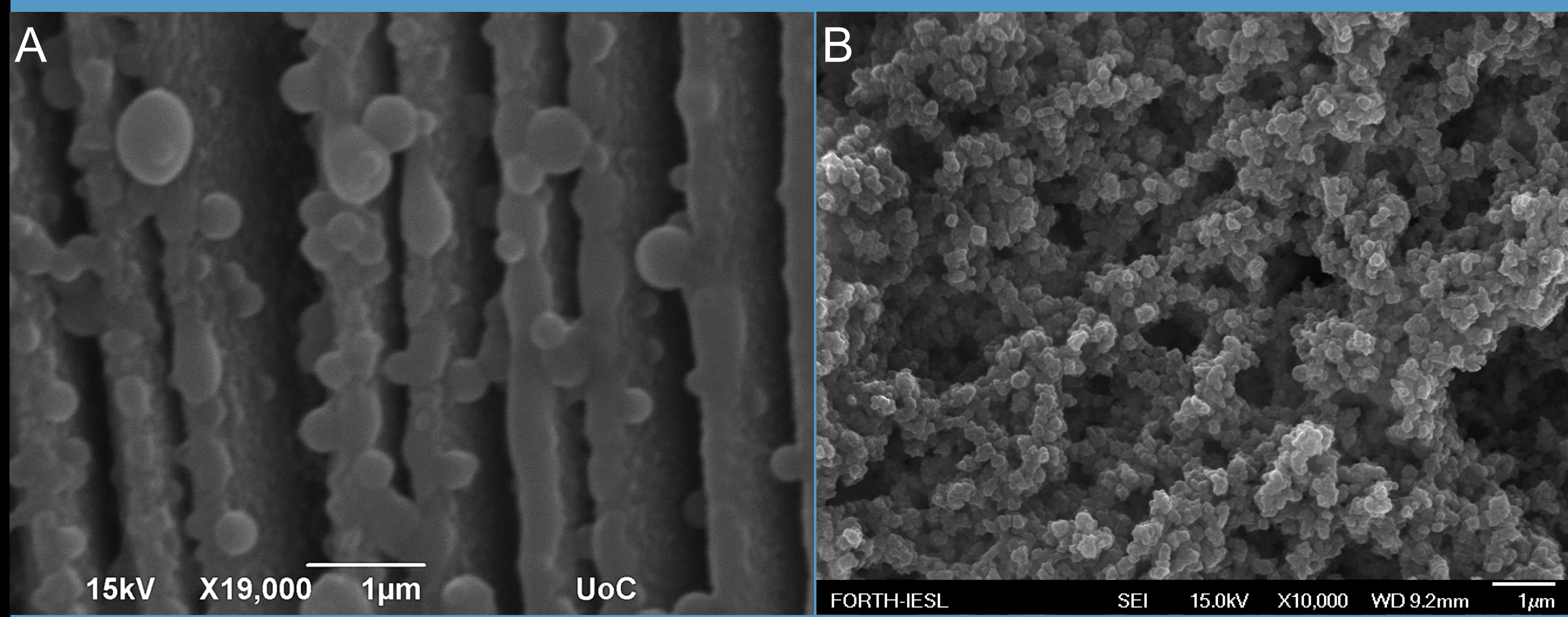


Nanoscribe system was used to fabricate suspended lines between cuboids. 1:1:9 (A), 1:1:5 (B), 1:1:2 (C) molar ratios of AIP:MAA:MATMS were used. D shows the arrangement of lines, where each corresponds to a different laser power and scanning speed.



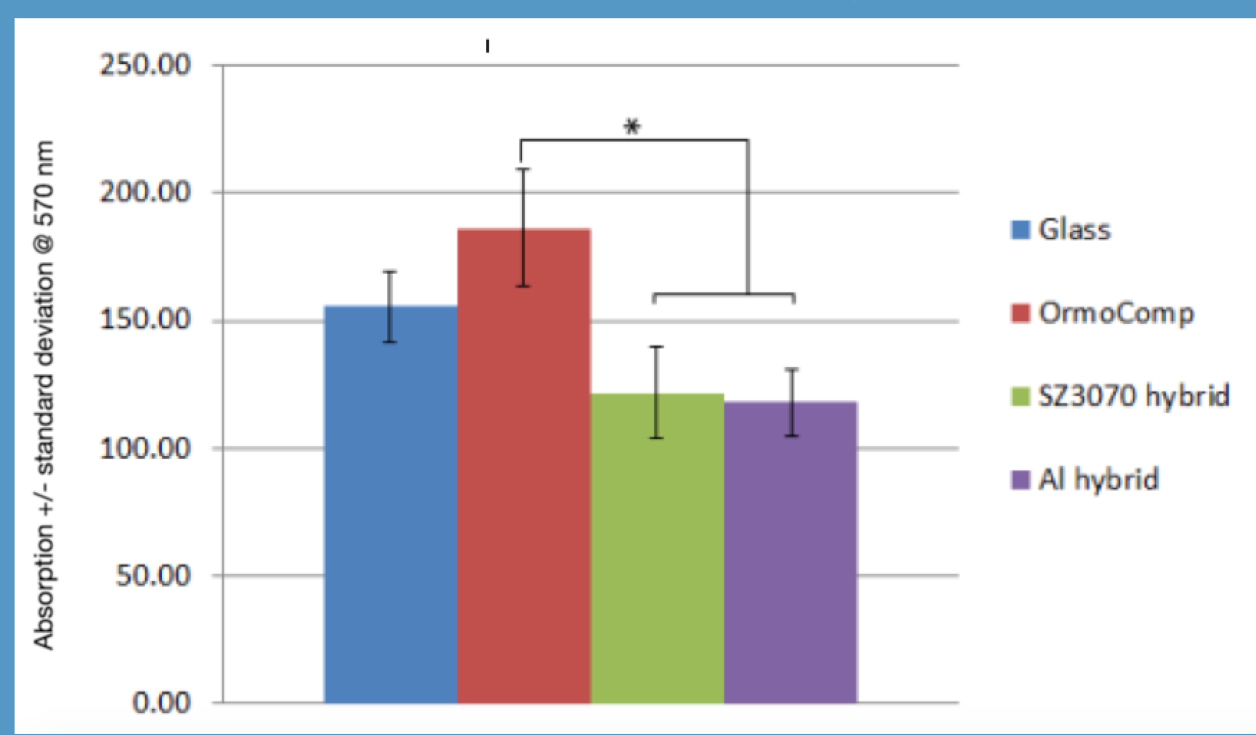
Results

Surface topography of polymerised and unpolymerised aluminium-based hybrid material.

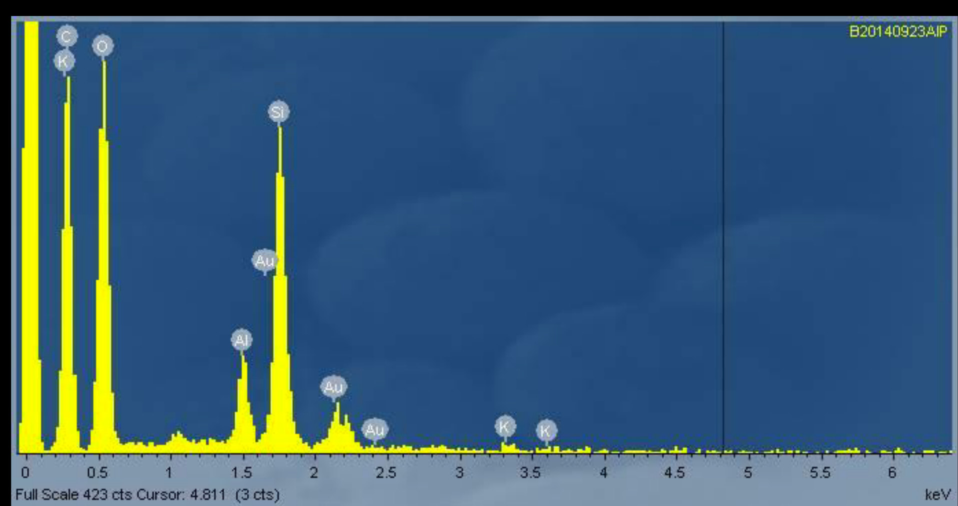


A – lines fabricated using 2 mm/s writing speed and 40X 0.8 NA objective lens. Nanoparticles can be seen on the polymer surface. B - a SEM micrograph of uncrosslinked Al- hybrid. The material shows a nanoparticle-based texture.

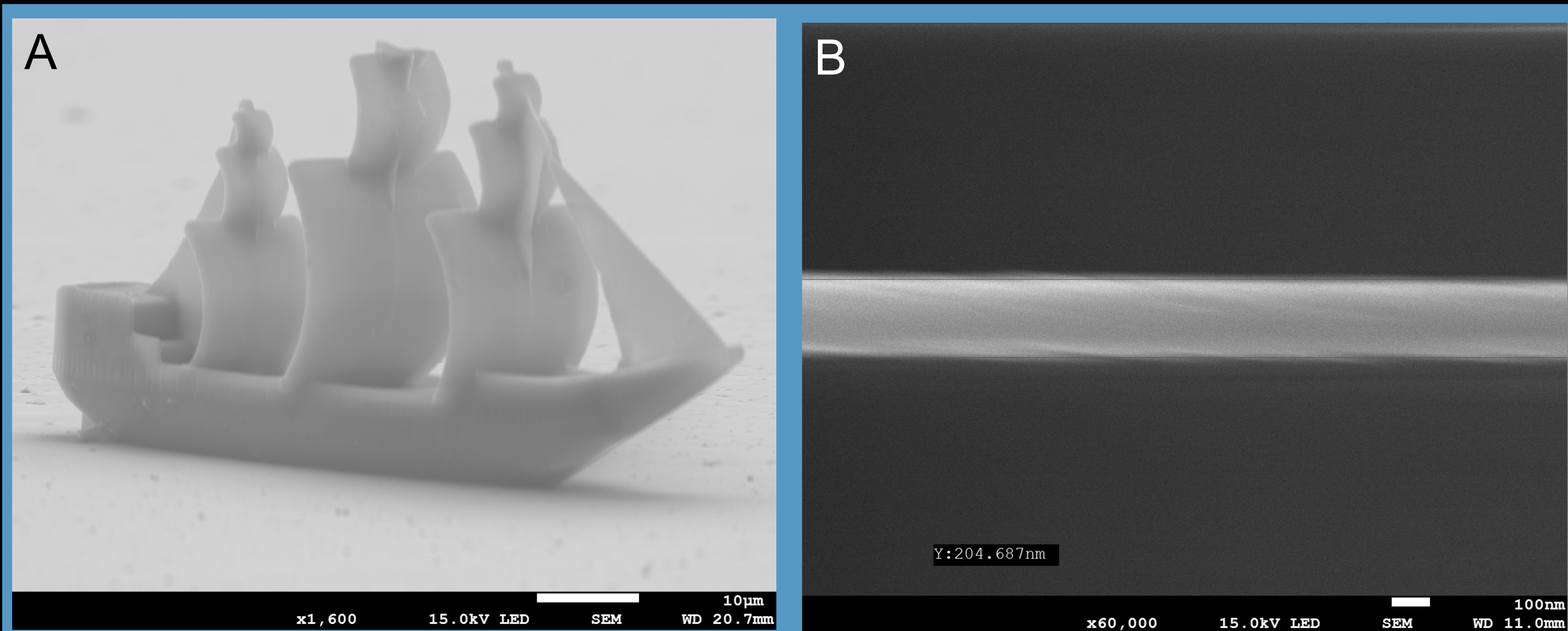
Biocompatibility



MTT assay was performed on NIH 3T3 fibroblasts grown on spin-coated and UV- cured hybrid polymer films. Results are presented as absorption +/- standard deviation, n = 16. Commonly used Zr- based hybrid material, SZ3070 (previously shown to be as biocompatible as a surgical suture [4]) was shown to be as biocompatible as the Al hybrid. Commercially available OrmoComp was shown to be the most biocompatible *in vitro*.



The presence of aluminium was supported by EDS spectra. XRD measurements show crystals of aluminium oxide present in the material (data not presented).



A - 3D structures with fine features can be fabricated. B - suspended lines with down to 200 nm can be fabricated. Both structures were fabricated using 40 % (20 mW) laser power and 10 mm/s scanning speed out of 1:1:2 material using a 63x oil immersion objective lens.

References

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Acknowledgements

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