Identifying 3D Printing Manufacture Techniques

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ABSTRACT

Understanding 3D printing technology is important in determining how to care for rapid prototype objects. Using non-destructive and small sampling techniques, four different printing methods – (1) fused-deposition modeling (FDM), (2) stereolithography (SLA), (3) selective laser sintering (SLS), and (4) drop-on-demand (DOD) – were characterized to identify their manufacturing method. Samples were analyzed with scanning electron microscopy (SEM), x-radiography (X-ray), and multimodal imaging.

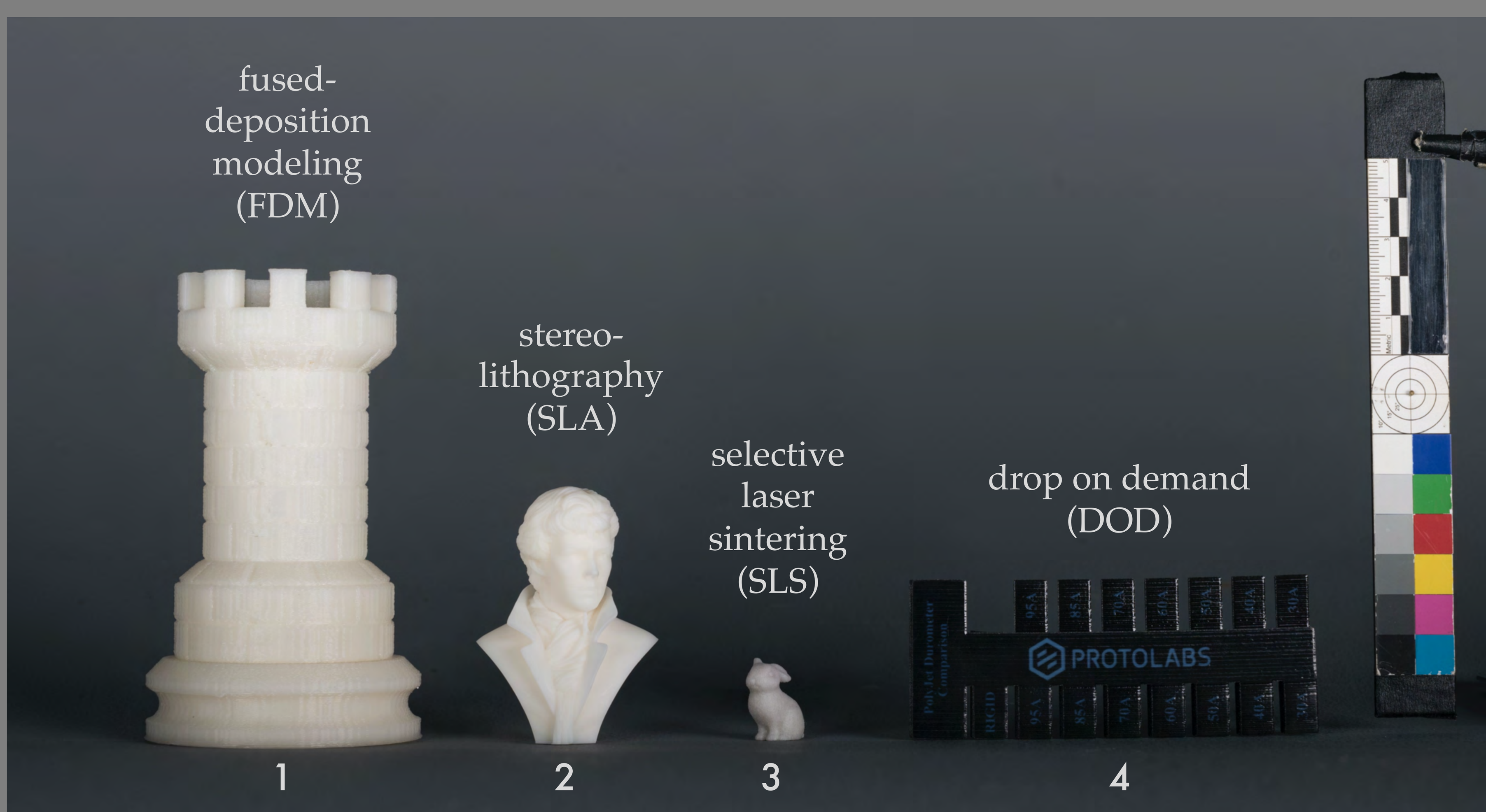

Figure 1: 3D printed samples photographed in normal light (N).

ANALYTICAL METHOD

Samples were initially investigated via multimodal imaging to establish any easily distinguishable characteristics of the printing technique (fig. 1,2,3,4 and 5). Multimodal imaging was executed with a modified DSLR. Cubes (1 cm^2) were then cut from each sample and were photographed using the same multimodal techniques and analyzed with scanning electron microscopy - energy dispersive x-ray spectroscopy (SEM-EDS) (fig. 8) and x-radiography (fig. 9).

Figure 2: Infrared Luminescence (IRLUM)

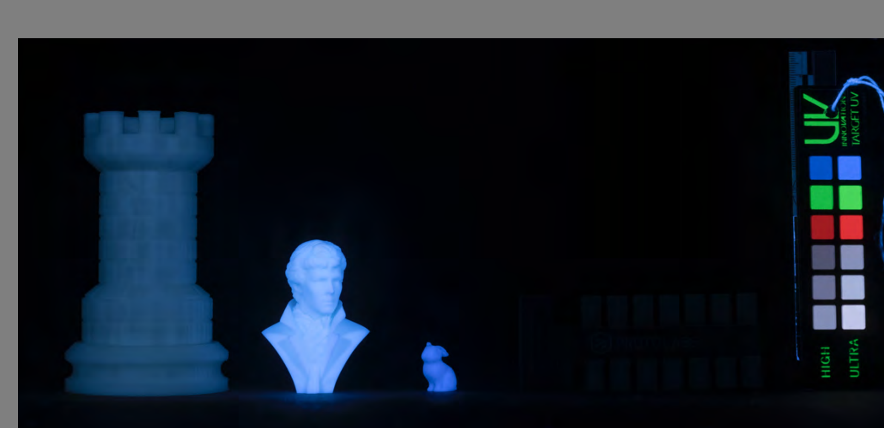

Figure 3: Ultraviolet induced visible fluorescence (UV-vis)

Figure 4: Reflected Ultraviolet (RUVA)

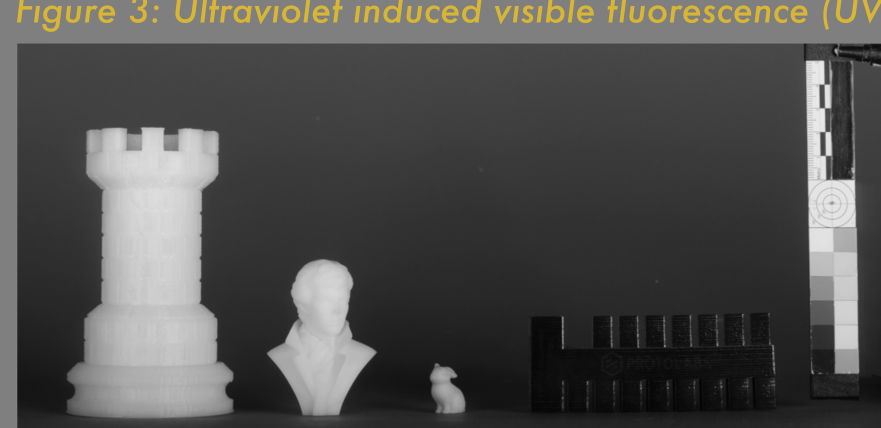

Figure 5: Reflected Infrared (IR)

OBSERVATIONS

Variations in sample size, shape, color, density and surface may be indicative of a sample group within a museum collection. However, these variables complicate direct comparison among manufacturing methods. For example, sample 1 (FDM) was the largest and lightest, while sample 3 (SLS) was the smallest and most dense. These variables were a direct result of their method of manufacture.

Sample 2 (SLA) appeared smooth with no visible steps in normal light. However, in reflected ultraviolet (fig. 6) these lines are visible due to differences in absorption. The glitter-like appearance of sample 3 (SLS) seen with infrared luminescence (detail in fig. 7), indicates the particulate nature of its constituents, as some of the powdery material used was not fully sintered.

Figure 6: Sample 2 detail, RUVA

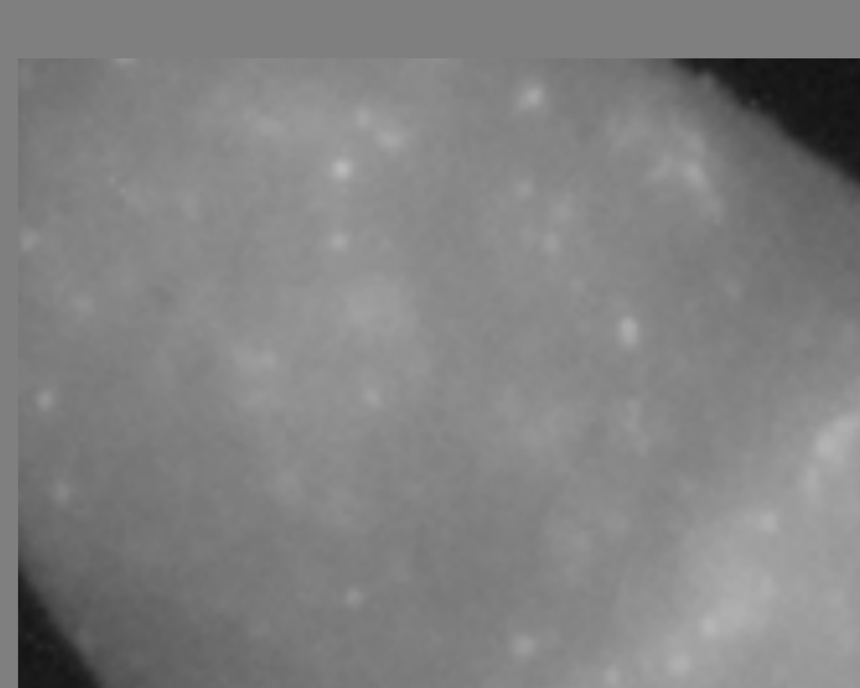

Figure 7: Sample 3 detail, IRLUM

OBSERVATIONS, cont.

Scanning Electron Imaging revealed a more detailed image of the surface texture of the sample as well as remnants from the curing, fusing, and smoothing processes (fig. 8). Multimodal imaging confirmed surface detail observed with SEM and some material clues. X-radiography and transmitted infrared confirmed that sample 1 was hollow (fig. 9).

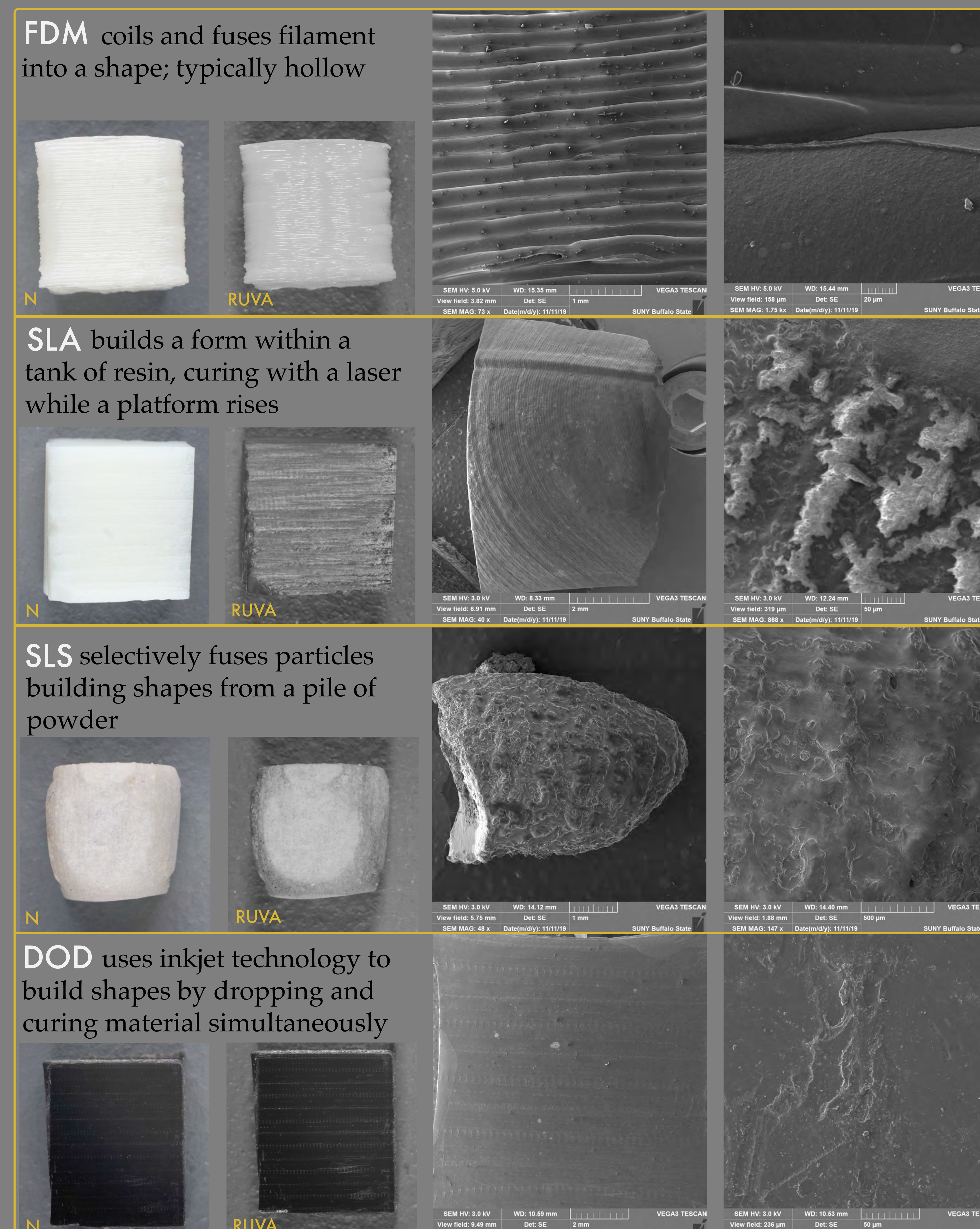

Figure 8: Images of each cut sample under N, RUVA, and SEM at two degrees of magnification.

FUTURE WORK

This study should be reproduced with samples from the same material/manufacturer and printed in a variety of methods. Study of samples which have been chemically and/or physically finished would also be valuable, as this is common practice. Testing aged samples could investigate how aging impacts observable characteristics and would more closely reflect objects in museum collections.

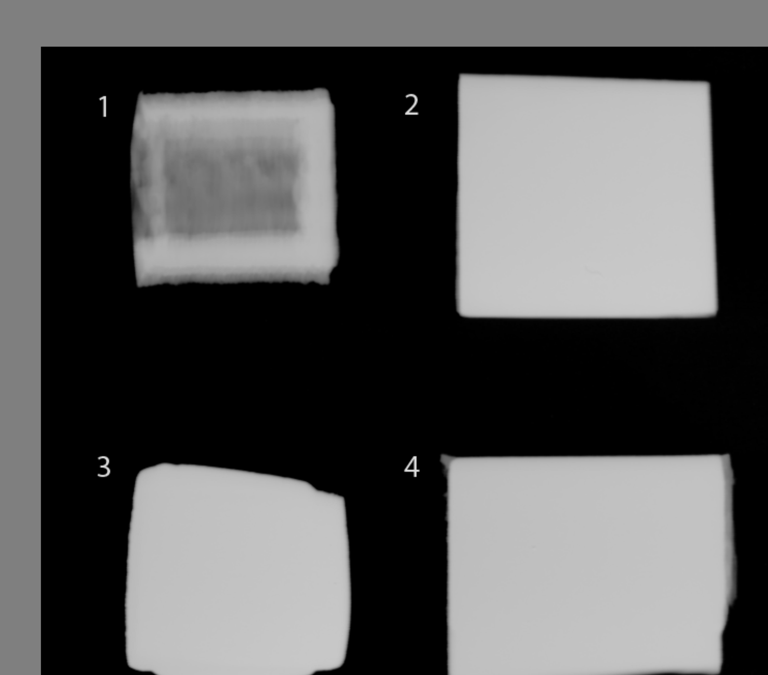

Figure 9: X-radiograph, samples 1-4

CONCLUSIONS

This research indicates that imaging with infrared luminescence, reflected ultraviolet, and ultraviolet induced visible fluorescence can illustrate notable differences between objects that may be linked to their printing technique. While this may be more dependent on material than technique alone, it is a first step to identification. If a small sample can be taken, SEM appears to be a valuable tool in revealing structural textures, dependent on manufacture. More research is needed to determine if these non-destructive or destructive sampling techniques can definitively identify method of manufacture.

ACKNOWLEDGEMENTS

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