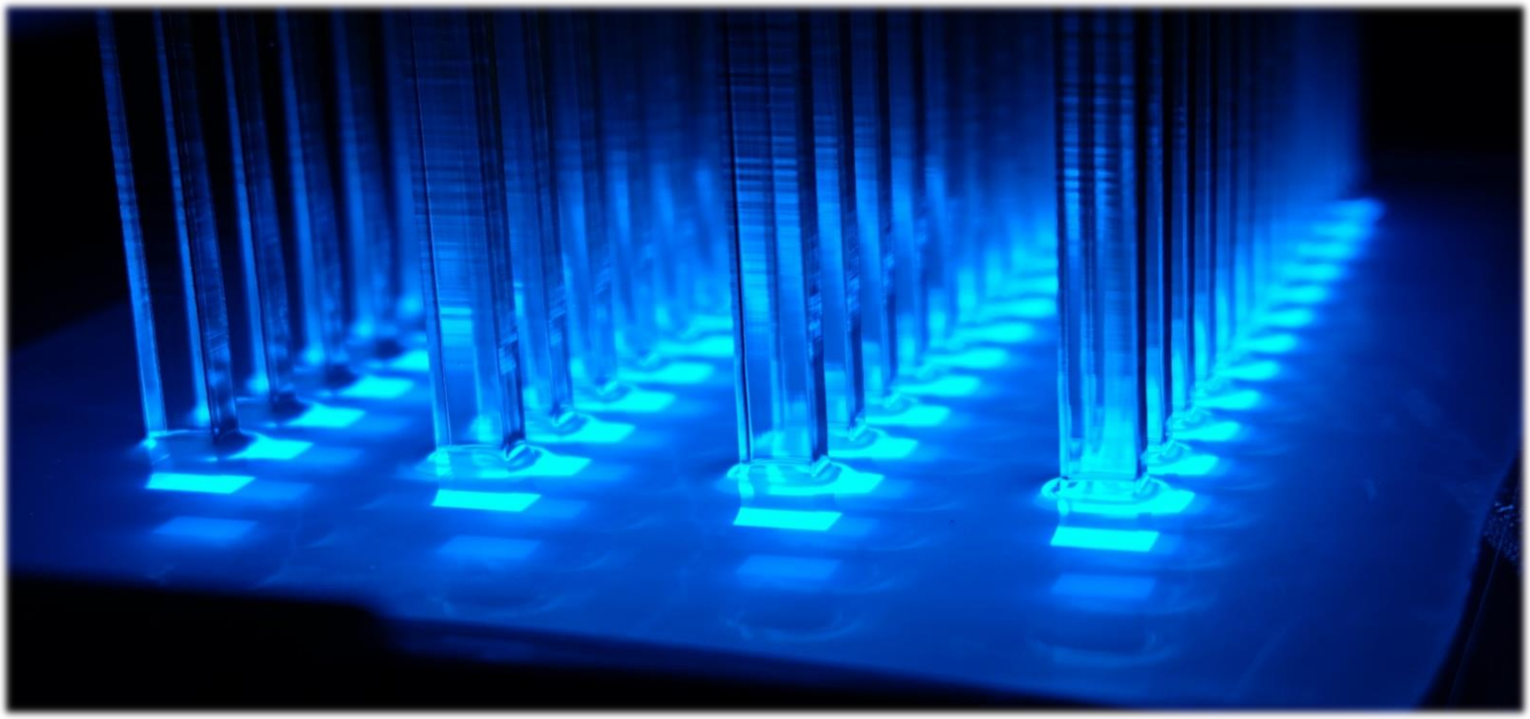

SUMMARY OF FINDINGS – OPTIMIZATION OF 3D PRINTED PART MECHANICAL PROPERTIES

A NewPro3D study in partnership with the University of British Columbia

Abstract

The purpose of this study, led by Dr. Chad Sinclair of UBC's department of Materials Engineering, is to measure the effects of print and post cure parameters in the NewPro3D process on the mechanical properties of 3D printed parts. In this study, exposure to UV light was varied to measure the effect of UV dosage on the final mechanical properties of a 3D printed object using the NewPro3D P-121 resin formulation. This study found that elastic modulus increased by 25% with 60 minutes of UV cure and that fracture stress increased by 6% with 45 minutes of UV cure. Beyond 60 minutes of UV post-cure, there were no significant increases in either elastic modulus or fracture stress for this specific material.

Introduction

NewPro3D produces DLP (Digital Light Processing) printers that produce solid parts from a photoreactive liquid resin by projecting and selectively curing one cross-section at a time using a projector that produces images using Ultraviolet light. When UV light strikes the photoreactive resin, a crosslinking reaction between photoinitiators and monomers begins, forming a solid part in a matter of seconds. As with any DLP printing system, parts produced using the NewPro3D process are printed in a semi-reacted “green state” in which the chemical bonding within the part is not driven to completion. Printing in this fashion allows NewPro3d to produce parts with exceptional accuracy. Once a print is complete, parts must be washed in 99% Isopropanol to remove excess resin from the surface of the object. After washing, an object can be used in it’s green state or post-processed in a UV chamber to complete the chemical bonding within the material and maximize mechanical properties such as elastic modulus and fracture stress.

Methods

To test elastic modulus and fracture stress, ASTM D638 Type II bars (Fig. 2) were printed using the NewPro3D NP1 printer at a vertical resolution of 100µm and a power density of 14.0mW/cm^2. Parts were then washed for 10 minutes in 99% Isopropanol before curing for varying times in a post cure chamber using a custom tensile coupon jig (Fig. 1) to ensure consistent and even dosage of UV light to each part.

FIGURE 1: ASTM TYPE II POST CURE SETUP

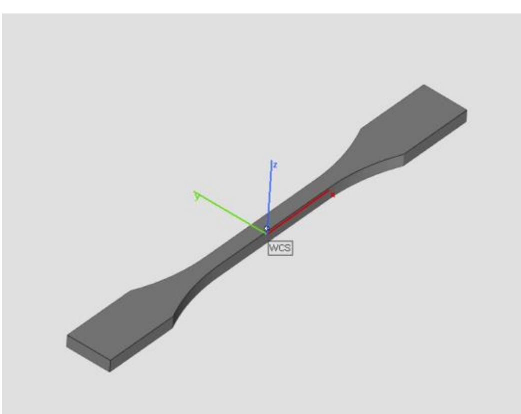

FIGURE 2: ASTM TYPE II TENSILE SAMPLE

10 samples were tested for each cure condition, the graphs below show the trend of Elastic Modulus and Fracture stress vs. UV cure time.

Figure 3 shows Elastic modulus increasing gradually with UV dosage until reaching a maximum of 60GPa. Figure 4 shows fracture stress increasing with UV dosage until reaching a peak at 30MPa. These results indicate that for this material, a 30 minute UV post-cure will yield an optimal combination of elastic modulus and fracture stress.

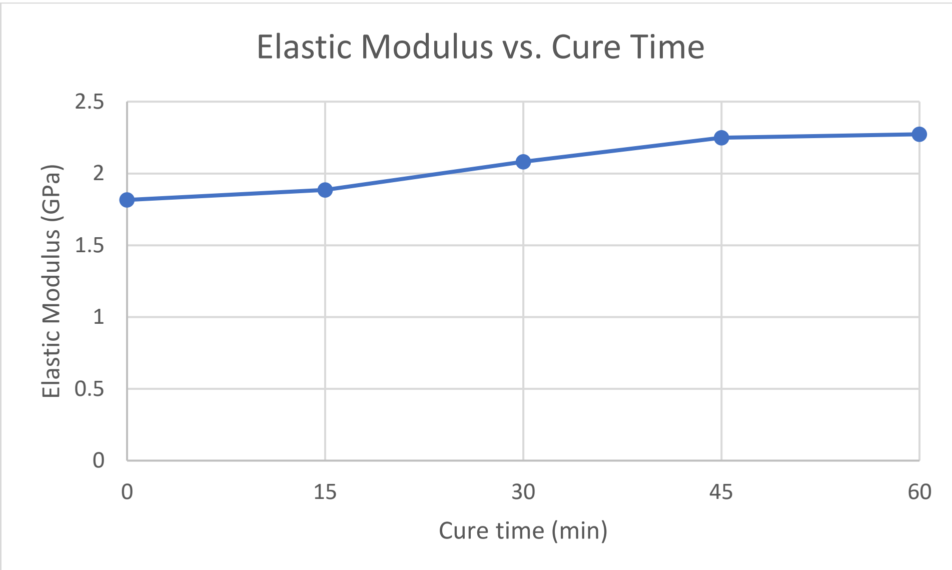

FIGURE 3: ELASTIC MODULUS VS. UV CURE TIME

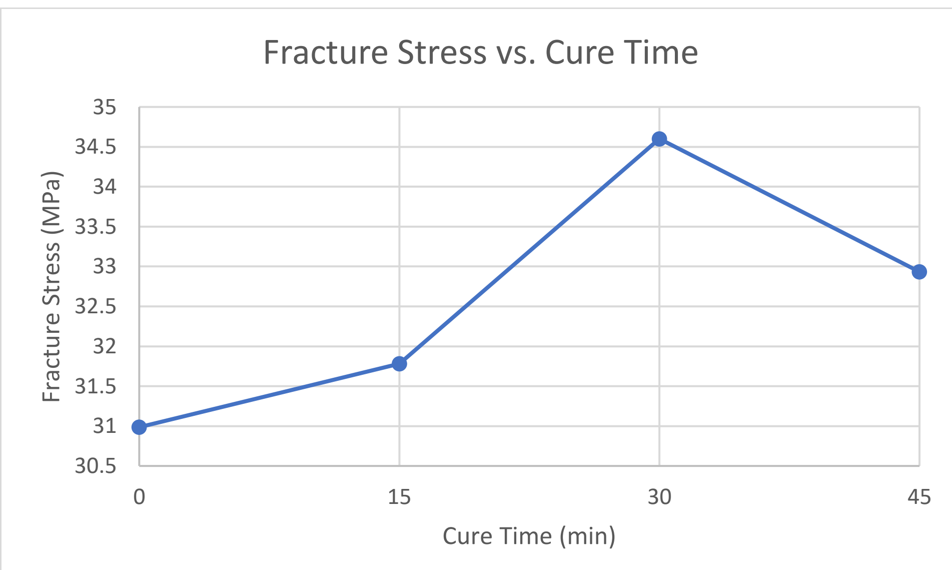

FIGURE 4: FRACTURE STRESS VS. UV CURE TIME

Conclusion

The results of this study show that both elastic modulus and fracture stress of parts produced using the NewPro3D process increase as a result of exposure to UV radiation. This is the expected result as the crosslinking reaction that forms solid objects in this process is incomplete until parts are exposed to additional UV dosage after printing. Further work is required to study the effect of temperature in combination with UV light on the mechanical properties of this material as it is expected to further increase elastic modulus and fracture stress of this material. NewPro3D also intends to repeat these tests on the remaining materials in their materials portfolio to determine optimal post cure parameters for each resin.