Digital Light Processing additive manufacturing of ZrO_2-Al_2O_3 ceramics

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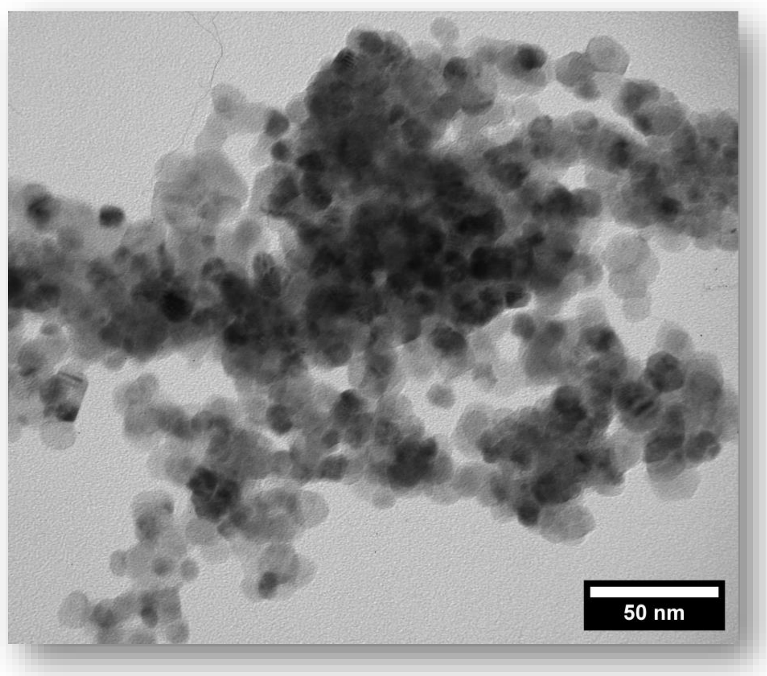
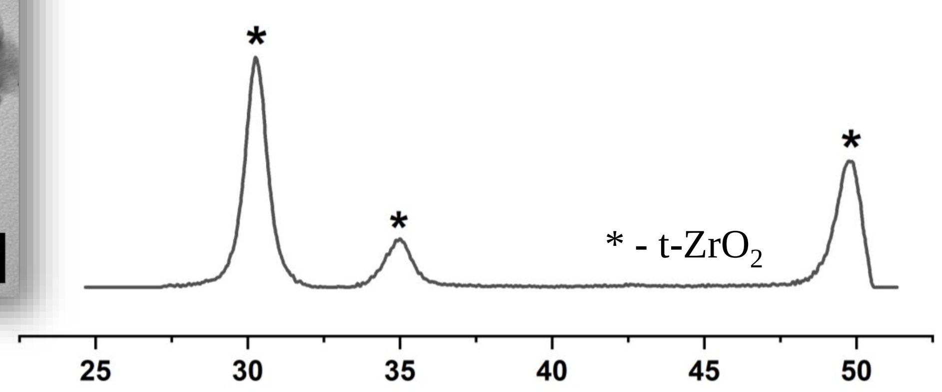
INTRODUCTION Ceramic materials based on zirconium dioxide (ZrO_2) and its compounds have good chemical resistance, high mechanical properties and are bioinert. Basically, ceramic products from zirconium ceramics are made using conventional forming methods such as isostatic pressing, casting, etc. However, those conventional methods have significant difficulties in making ceramic parts with complex structures. Additive manufacture, particularly, digital light processing (DLP) is demonstrating significant technical advantages in making complex shaped ZrO_2 products over the conventional processes. The presence of a small amounts of colored additives affects the photocurability, and printability of the ceramic composite resins. Therefore, it is necessary to develop colored ceramic powders based on ZrO_2.

Powder characteristics

Powder of ZrO_2 containing 3 mol.% of Y_2O_3 doped with 10 wt.% of Al_2O_3 (10ATZ) produced by chemical coprecipitation at room temperature.



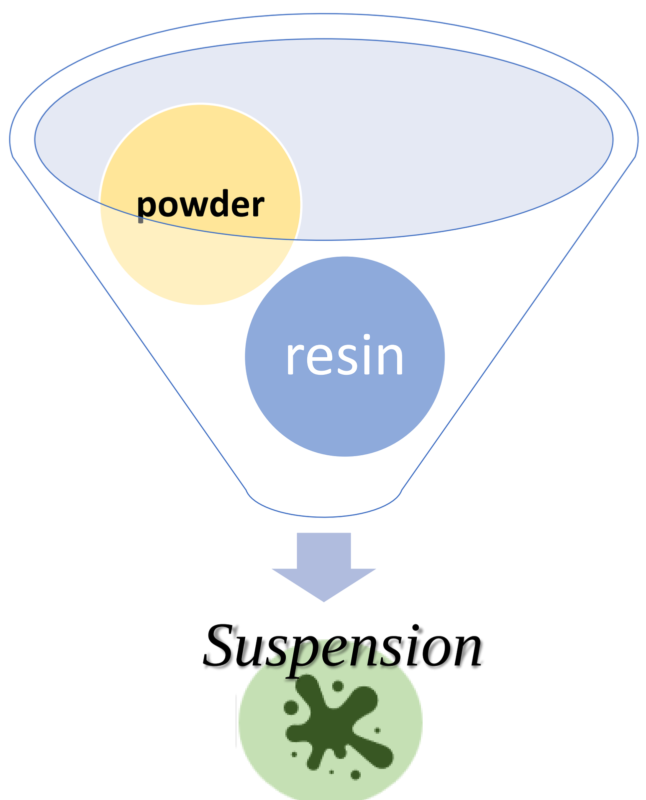
	S_{BET}, m²/g	D, nm
10ATZ	47±2	10

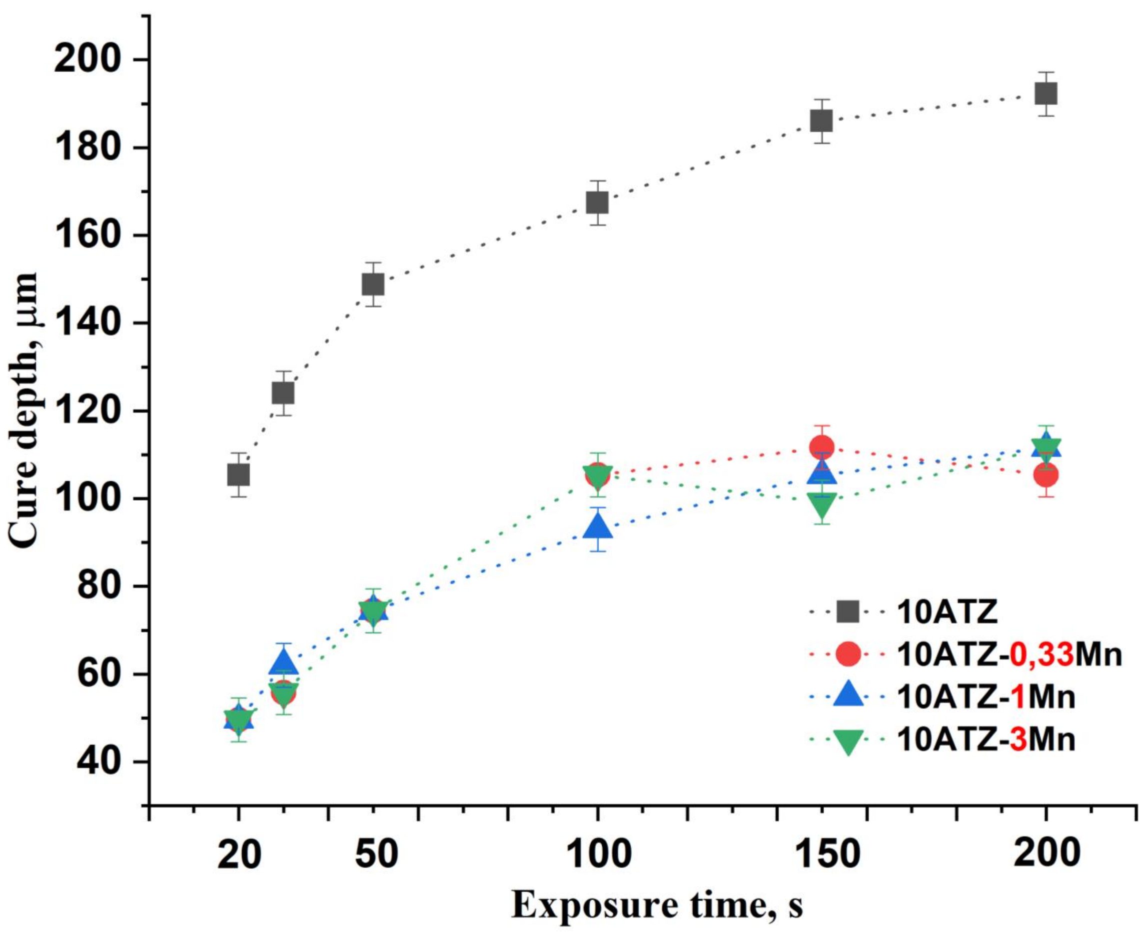


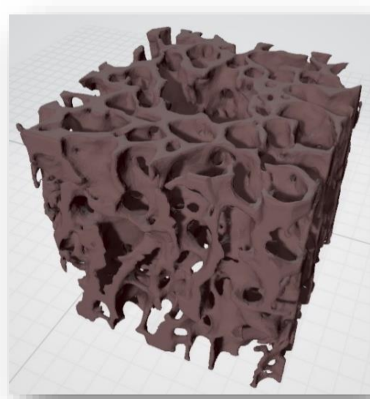
TEM and X-ray patterns of the synthesized powders

Ceramic fabrication by DLP 3D printing

To form samples using DLP 3D printing, photocurable ceramic suspensions were used, which were prepared as follows: the powder was mixed with a photoactive resin based on a liquid benzophenone-type oligomer. The objects were printed using a DLP 3D printer Anycubic Photon S (China) with a layer thickness of 35 μm and an exposure time of 60 s.

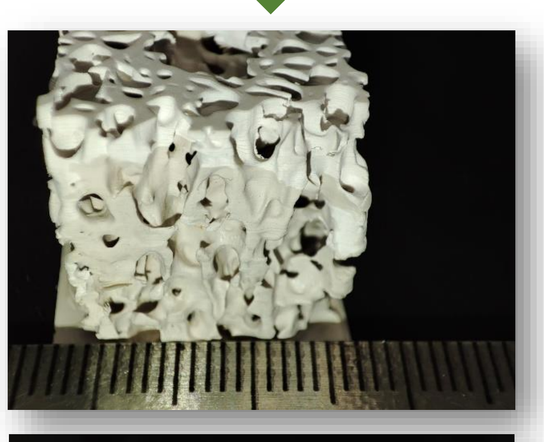




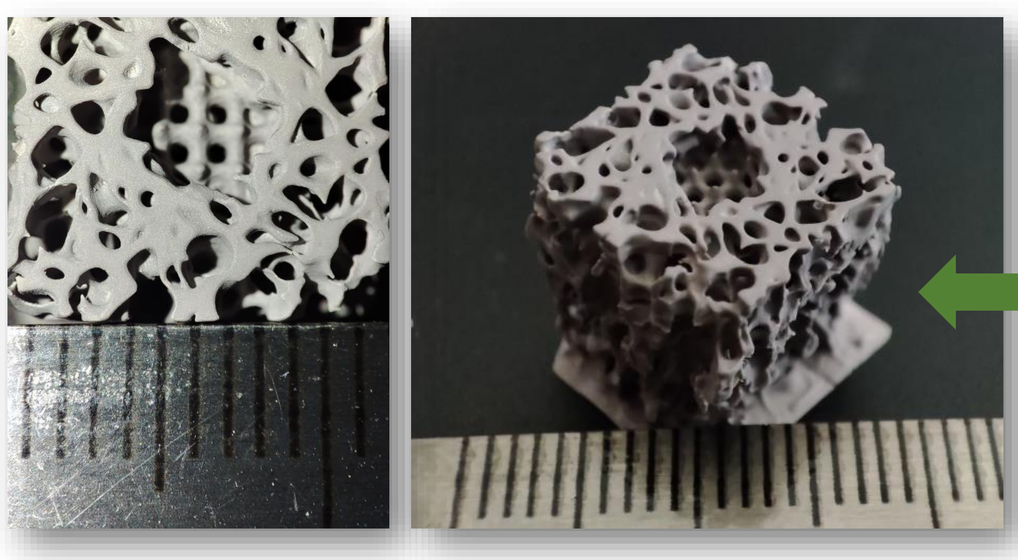


Bone structure model

3D printing

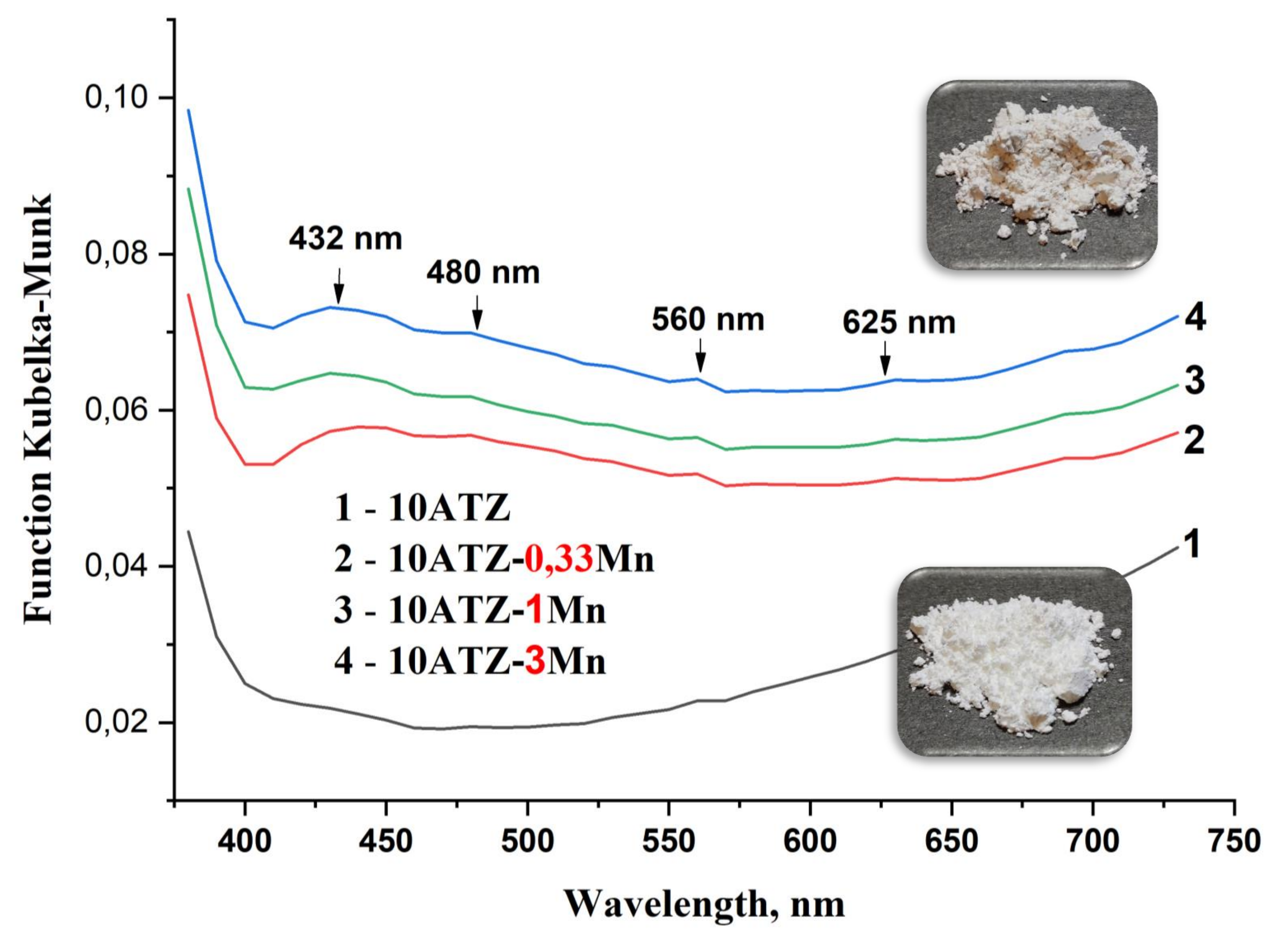


Green body

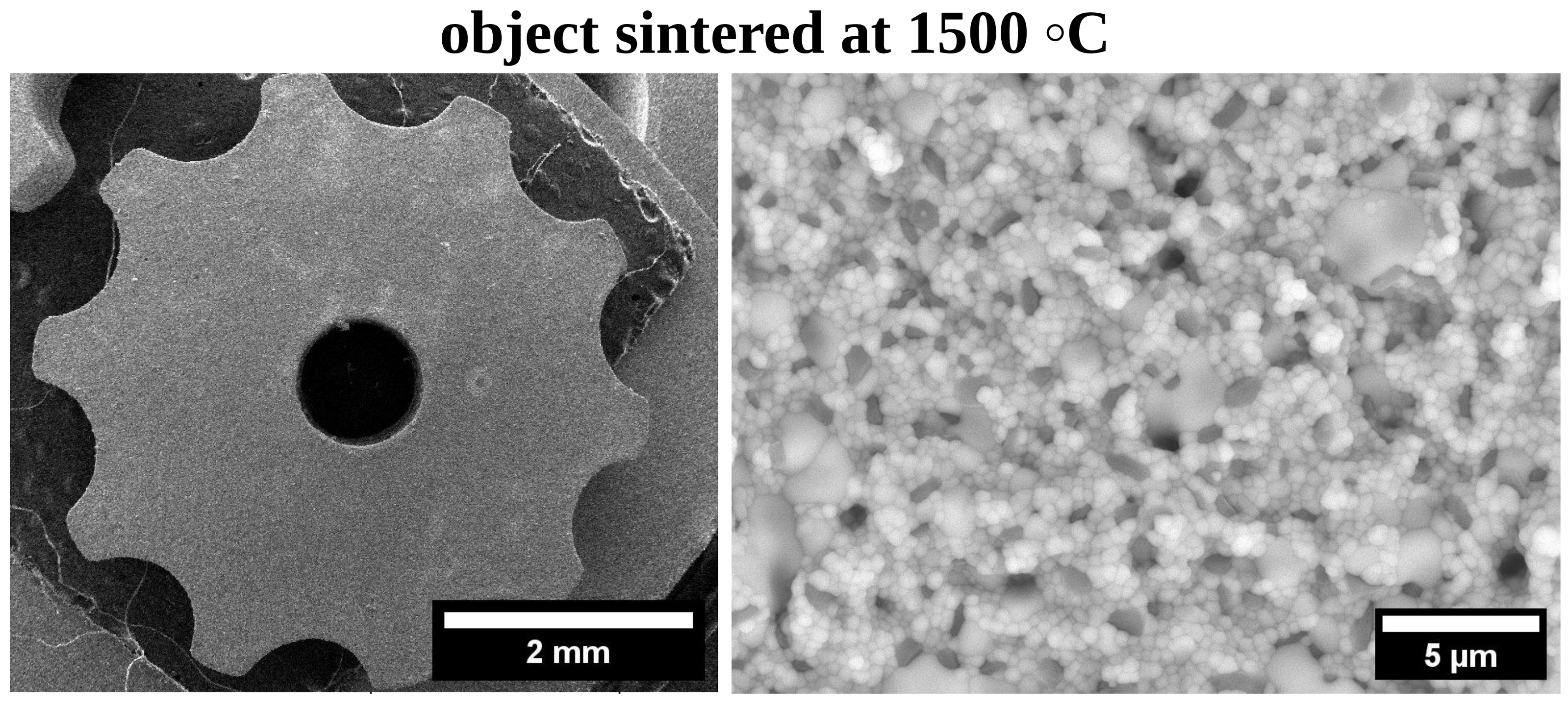


Sintered at 1500 ◦C

Manganese oxide (MnO) was added in the form of the soluble salt $Mn(CH_3COO)_2{\cdot}H_2O$). The amount of the additive was evaluated from MnO content:
0, **0.33**, **1.0**, and **3.0** mol.% relative to the 10ATZ.



The optical photos and SEM micrographs of 10ATZ-0,33Mn object sintered at 1500 ◦C



Object	HV, GPa	K_{1c}, MPa·m$^{1/2}$
10ATZ	8,5±0,4	6,4±0,3
10ATZ-0,33Mn	11,7±0,6	6,9±0,3

CONCLUSIONS The light absorption of the pure powder 10ATZ and 10ATZ-**Mn** were investigated. It was found that the absorbance of powder containing manganese oxide increases with the additive. The cure behavior investigation on the ceramic suspensions during DLP process shows that as the concentration MnO the cure depth increases decrease due to the ceramic suspensions absorbance. 10ATZ-**Mn** ceramics have been successfully fabricated by DLP technology.
The 10ATZ-0,33Mn objects are characterized by 11.7 GPa microhardness.