Metallic Scaffolds by Reduction of 3D-printed Oxide Inks

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Abstract

We present a novel approach to metal additive manufacturing in which inks consisting of metal-oxide particles, are 3D-printed via direct ink writing (DIW) into self-supporting, cellular structures which are transformed into metallic counterparts through debinding, thermochemical reduction and sintering in hydrogen. We show that a wide variety of cellular metals (e.g., Fe, Cu, Ni, Co, W) and alloys (e.g., Cu-Ni, Fe-Ni, Fe-Ni-Co) can be fabricated from inexpensive submicron metal oxide powders using simple equipment, thus reducing cost and energy foot-print of as compared to more traditional methods based on laser or e-beam additive manufacturing of micron metallic powders. We also investigate the kinetics of debinding, reduction and sintering using synchrotron x-ray diffraction and tomography, to shed light on the partially-overlapping sintering, interdiffusion and densification processes.

Short Biography

Dunand holds a BS/MS from ETH (Zurich) and a Ph.D. from the Massachusetts Institute of Technology where he was on the faculty until 1997, when he joined Northwestern University (NU) where he is now the Professor of Materials Science and Engineering. In 2008, he was the founding co-director of the Initiative for Sustainability and Energy at Northwestern (ISEN) and he held this position until early 2015. Dunand holds over 12 patents and has published over 340 journal articles. His research focuses on processing, structure and mechanical properties of metallic alloys, composites and foams. Dunand is a fellow of ASM International and of TMS. He has received several awards, including the 2012 *Materials Science & Engineering A Journal Prize*, the 2009 *Distinguished Scientist/Engineering Award* Structural Materials Division of TMS and twice a departmental *Teacher of the Year Award* at NU. Dunand is co-Founder and co-Chief Scientist, together with Prof. David Seidman, of NanoAl, LLC, a start-up company developing novel high-temperature alloys at the intersection of nano-, energy- and green tech.