Additive Manufacturing of Ceramics using Inorganic Polymers

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Preceramic polymers convert into nanostructured Si(X)OCN (X = Al, Ti, Zr, etc.) ceramic materials by high temperature pyrolysis. We fabricated porous structures of advanced silicate ceramic phases, including bioceramics, starting from preceramic polymers (e.g. silicones) and also reactive fillers. Different types of additive manufacturing (AM) techniques were employed, including: a) fused deposition; b) direct ink writing; c) powder-based indirect printing (in collaboration with BAM, Germany); d) stereolithography. Advantages and disadvantages of the different techniques with related examples will be discussed.

Geopolymers are inorganic 3D networks usually obtained through reaction of alumino-silicate powders in a silicate alkaline solution. They consolidate at low or even room temperature, show intrinsic micro- and meso-porosity, good mechanical properties, chemical durability and stability up to 1200°C.

We explored, for the first time, both direct and indirect AM technologies using a geopolymeric binder of optimized rheology. Since the mixtures are reactive, we could consider this to be a 4D printing process.

In collaboration with a company (Desamanera, Italy), a geopolymeric binder mixture was sprayed on a bed of marble powder, resulting in large scale parts (up to 6x6x6 m^3) with improved mechanical properties compared to the use of non-hydraulic binders. For direct ink writing, geopolymer pastes were developed and used for the fabrication of highly porous 3D lattices.