Electrification of Materials Synthesis

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The advent of flash sintering, first published in 2010, where it was shown that zirconia could be sintered in a few seconds at temperatures well below 1000^{o}C has now been followed by revolutionary new developments most notably synthesis of complex materials with unusual properties, prepared under far-from-equilibrium conditions, under the influence of electrical currents. Both metals and ceramics are amenable. The basic tenet of this phenomenon is the generation of colossal concentrations of defects, which are so numerous as to form their own phase, confirmed by advanced TEM techniques in single crystals of cubic zirconia. Our latest experiments are showing a continuum where the defects become so numerous as to evolve into a "molten state" by a second order phase transition. Solid state diffusion rates that are eight orders of magnitude higher than handbook values have been measured; they are like the near universal value of the diffusivity of metals at their melting points. Other developments include non-stoichiometric solid-state electrolytes for Li+ batteries, and the synthesis of graphene infused copper with a significantly higher conductivity than the benchmark gold standard of 58 MS/m, also known as the International Annealed Copper Standard (IACS). "Flash" is now being used to accelerate chemical reactions for example conversion of zinc sulphide into an oxide. Applications in solid state chemistry are on the horizon. This presentation summarily covers a few of these topics.