Making High-Strength High-Ductility Composites Through SPD Process –

A Polymer Derived Ceramic Metal Matrix Composite

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Among the many challenges facing humanity that it needs to overcome to lead a sustainable life, two of them are

1) Control of Young's modulus, yield strength and ductility of a material through use of a single component (mono) system.
2) Complete recycling of such non-replenishable materials

In fact, the second can easily (or ever) be achieved only in the first is achieved. In this talk the principles of sustainability, which is binary, is covered first. We then introduce a new class of materials that is being developed in both SIAM Lab, IISc and DAMAS, University of Lorraine. The material is the Polymer Derived Ceramic (PDC) Metal Matrix composite (MMC) - PDCMMC. In this material a polymer, that converts to a ceramic is mixed with a metal matrix (in this case aluminum). The mixing is done using severe plastic deformation route. The severe plastic deformation also leads to fracture of the polymer particles to nano-sized particles. The polymer composite is then heated to pyrolyze this to a ceramic. A further processing is done to eliminate the porosity produced in the material during the pyrolysis. The advantage of using the polymer is that one gets nano-sized (of even up to 1 nm) particles of ceramics. Getting such sized ceramics by directly powdering ceramics is a near impossibility as the fracture process gets more difficult as the particle size reduces. This is because the defect density in a ceramic particle reduces as the size reduces (for example, in SiC the minimum particle size used is around 40 nm). By controlling the amount, size and distribution of the PDC particles in the matrix, one can control the Young's modulus (to a lesser degree), yield strength and ductility of the material. The discovery of a new class of foamed material during the work done on PDC-MMC will also be presented.