3D nanostructuring of Graphene and related materials using macroscopically expanded 3D ceramic networks as a versatile template

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The fabrication of three dimensional (3D) architectures (such as sponges, foams, aerogels, etc.) from Graphene and its related materials is an extensively studied field due to their broad range of applications in the areas of electronics, energy storage, healthcare, catalysis as well as environmental protection[1]. However, the utilization of such materials and their extraordinary properties, like the high tensile strength of 63 GPa for CNTs or graphenes lowest electrical resistance, is typically limited by the lack of advanced structural design[1]. Macroscopic foams from such low-D materials are typically manufactured either by chemical vapor deposition (CVD) processes or by wet chemical approaches, such as freeze-drying. In the here presented study a versatile, highly porous (up to 98%) ceramic template[2] material is introduced for the 3D structuring of low-D nanomaterials, such as graphene, hexagonal boron nitride (h-BN) and carbon nanotubes into hierarchical macroscopic (cm^3-scale) assemblies. Using a simple wet chemical infiltration process, the sacrificial template can be homogenously coated with 1D and 2D nanomaterials, by using sophisticated dispersions.[3] Furthermore, the ceramic template can be used as a template material in CVD processes for the growth of other graphene related nanomaterials, such as h-BN and graphite.[4] In either case, the removal of the template results in free-standing, highly porous and light weight 3D nanoarchitectures consisting of interconnected hollow microtubes with nanoscopic wall thickness (see Figure 1). Such templates offer a high degree in fabrication flexibility and a combination of different nanomaterials can be achieved, leading to complex 3D composite architectures with special properties.

References

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Figures

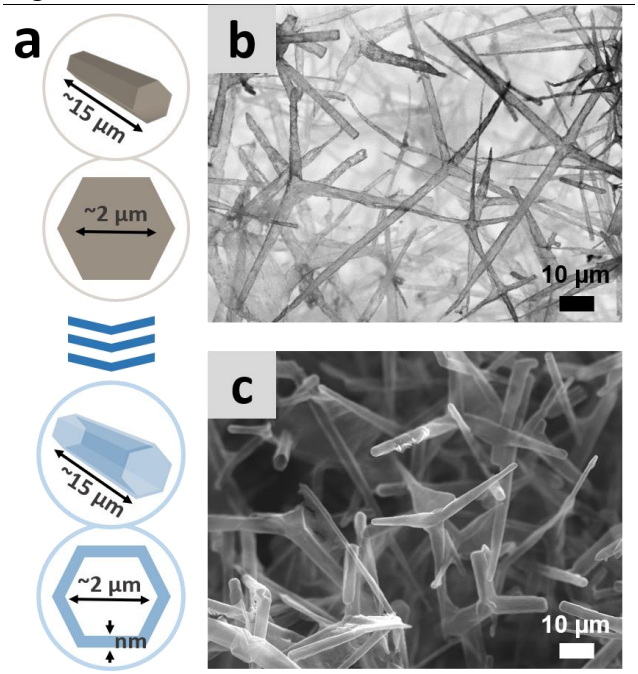

Figure 1: (a) Schematic illustration of the synthesis process: 3D interconnected microtube nanoarchitectures of **(b)** h-BN and **(c)** graphene are obtained using the same ceramic template consisting of interconnected ceramic microrods. The h-BN structure is grown by CVD techniques whereas the 3D graphene structure is wet chemically formed by a self-organization process.