HIERARCHICAL HYBRID MATERIALS FOR ROBUST & REUSABLE FUNCTIONAL DEVICES

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Nano-scale solids are known to offer significant advantages related to surface activity and quantum control, but their incorporation in engineering devices is often limited by challenges realted to handling, storage and assembly combined with environmental proliferation risks. Many natural living systems address these challenges through elegant multi-scale hierarchical designs such as microvilli and dendrites, where a larger substrate is covalently anchored to progressively smaller functional entities. This type of architecture offers exceptionally high levels of solid-fluid interaction in very compact space for important functions such as load distribution, digestion, electrochemical exchange, and sensory behavior. However, this design has been traditionally avoided in engineered devices due to the complexities of creating primary bonds across components having different sizes, shapes and compositions to form a single continuous solid. In recent years, advances in surface science and nanoscale processing have made it possible for our team to fabricate these types of materials, which provide very significant advantages over conventional solids.

This talk will provide insights into selected materials that have shown promise in solid-fluid interaction devices such as catalysts, electrodes and sensors. A typical example is shown in Figure 1, where covalently bonded carpet-like arrays of electrically and thermally conducting carbon nanotubes (CNT) have been attached on porous carbon membranes using a two-step technique developed by this team. The nanotube carpets can create 1000-fold increase in surface area, without any significant change in weight or volume. These nanostructured surfaces can be further functionalized with selected coatings and catalytic nanoparticles for tailoring their fluid/matrix permeation, bio-interaction, chemical, catalytic, and electrical properties. Materials fabricated by this team have demonstrated unique properties suitable for a diverse variety of applications such as composite reinforcement, charge storage, gas and pathogen sensing, tissue engineering scaffolds, and water purification membranes.

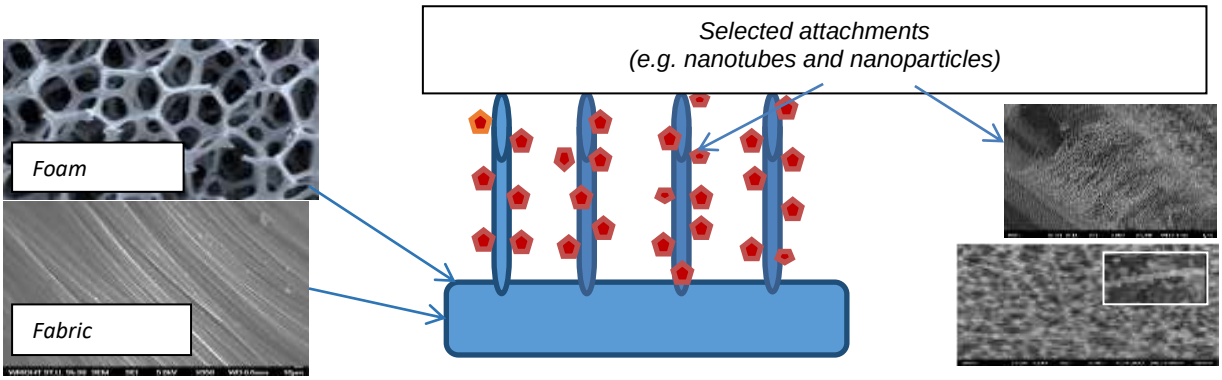

Figure 1:Example of durable and reusable hierarchical hybrid materials. Carbon nanotube carpets covalently attached on suitable surfaces such as graphitic foam (top left) or fabric (bottom left). Additional nanoparticles and coatings are attached based on functionality.