Chemical vapor deposition: dirty chemistry or clean materials?

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Thin films and micro- or nano-dimensional coatings play a role in many everyday devices and future high-tech applications. For example, computers, cameras and mobile phones owe some of their functionalities to the magnetic, photo-active or conductive layers, mostly on silicon chips, that enable capture of images and signals as well as data storage and retrieval. The broad range of use for supported nanoparticles and films includes many other areas, for example in catalysis, photovoltaics and energy conversion, wear resistance and protection, and functional coatings are also found in optical devices and sensors.

Control over the materials' properties is extremely important, since contaminations, even if at very low levels, can limit lifespans and desired properties of devices. On the other hand, when doping strategies are applied, i.e. when a "contamination" is intended and controlled, a material may assume additional or novel functions that may render it more useful than the host material itself.

Chemical vapor deposition (CVD) is a process which offers an enormous flexibility for obtaining films and deposits with desired properties. In principle, a chemical, the precursor, is transported to the substrate or surface of choice, and upon a suitable activation (thermal, or induced by photons or by a plasma) it reacts to form the material of choice. The process relies upon a complex interaction of transport, fluid dynamics and chemistry near and at the surface, which offers many variables for optimization, but makes it often appear as an empirical, "alchemistic" system rather than one understood in fundamental detail.

We have recently been able to demonstrate that clean, conductive, ultrathin films of transition metals can be obtained by a novel CVD approach, including Cu, Ag, Co, Fe, and Ni, which are highly desirable for a variety of applications. Also, very similar deposition strategies can be used to make spinel and perowskite type oxides, again materials with a perceived high potential in catalysis and energy storage. Promising combinations of metals, bimetallic layers, nanoalloys and conductive, insulating or protective oxides seem attainable this way, potentially using the same reactor.

It is our specific aim, from the viewpoint of Physical Chemistry, to not only make the materials, to optimize their deposition and to characterize their properties, but to understand the mechanisms of their formation, with the goal to ultimately control the "lego-type" assembly of materials and their combinations from the individual building blocks.

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