Chemical Vapor Deposition of Polymers: Fundamentals and Applications

by

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Abstract

Traditionally, chemical vapor deposition (CVD) is used for the formation of inorganic and metallic thin films to make micro- and nanoscale integrated circuitry that has propelled the electronics industry to the forefront. More recently, CVD has been explored for the formation of organic polymer thin films with a focus towards achieving true polymers with well-defined repeat (mer) units that can make full use of the properties of the polymers. This push will be instrumental in enabling future technologies, such as in energy, medicine, and electronics, where a flexible polymer-based platform would be attractive and necessary, especially as these technologies shrink in size and scale.

Here, initiated and oxidative chemical vapor deposition (iCVD, oCVD) will be presented as unique and viable approaches for producing well-defined polymers without the use of a liquid or solvent medium. The iCVD and oCVD techniques enable the synthesis of polymer thin films by tailoring polymerization reactions and reaction mechanisms that have been successfully performed in the liquid phase. However, by enabling these reactions to occur without a liquid reaction medium and under a low pressure gaseous environment, polymers can be coated directly onto a substrate in the form of thin films that conform very uniformly to the topology of the substrate. In eliminating the liquid phase, interesting kinetic phenomena related to the polymerization process appear. Here, fundamental insights into gas and surface diffusion and surface reaction kinetics that influence deposition behavior will be discussed.

Coupling the abilities to tailor polymer chemistry and film formation, the iCVD and oCVD approaches offer unique opportunities in the development of a wide range of end uses. Here, several applications will be detailed that take advantage of these CVD methods in achieving conformal deposition within 3D porous geometries. Specifically in the area of energy, the integration of polymer electrolytes in dye sensitized solar cells (DSSCs) and redox polymers in supercapacitors will be discussed. The ability to achieve tight integration provides significant enhancements in device performance. Other emerging areas related to surface tailoring that lead to interesting phenomena, such as superhydrophobicity and directed surface patterning, will also be presented. These examples serve to illustrate the versatility of the CVD methods in the design and fabrication of polymer thin films and devices.

Short Bio

Prof. Ken Lau is an Associate Professor in the Department of Chemical and Biological Engineering at Drexel University. He currently serves as the Assistant Department Head and the department's Graduate Advisor. He received a B.Eng.(Chemical) from the National University of Singapore in 1995 and a Ph.D. in Chemical Engineering from the Massachusetts Institute of Technology in 2000. He was a research fellow at the Institute of Materials Research in Singapore and a postdoctoral associate at MIT before joining Drexel in 2006. He received the NSF Career Award in 2008 and was the PI on a $1.125M NSF MRI Grant in 2010 for acquiring a
state-of-the-art X-ray photoelectron spectrometer. He was a Visiting Associate Professor at the Hong Kong University of Science and Technology in 2013 as part of his six-month sabbatical after receiving tenure. He is currently serving on the International Advisory Board of the International Hot Wire CVD Conference, and most recently chaired and organized its 9th international conference in Philadelphia in 2016.

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