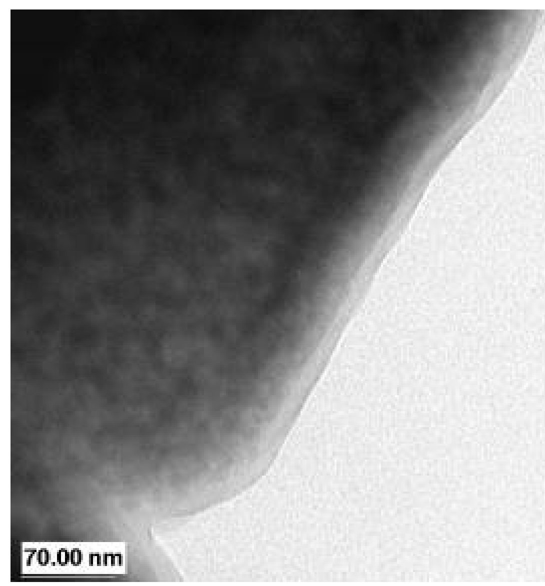
Polymer ALD™

Overview: In order to increase strength, conductivity, or add barrier properties, it is desirable to put dense thin films of ceramics or metals onto polymer objects, films, or particles. Placing inorganic films on these thermally delicate substrates such as polymers has previously been very challenging. Methods such as plasma-enhanced chemical vapor deposition (PE-CVD) and sputtering have been shown to deposit films without damaging substrates. However, the films produced by these techniques are typically not bonded to the substrate and are not complete dense films as would be required for barrier applications.

Market Overview: Development of adequate barrier films onto polymeric substrates is currently limiting the implementation of organic light emitting diodes and other novel technologies in the displays and electronic industries. According to DisplaySearch, the $112 million worldwide OLED market in 2002 will grow to $3.1 billion by 2007. Additional applications for Polymer ALD™ are in the lower cost manufacture of polymer/ceramic nanocomposites. The demand for polymeric/ceramic nanocomposites is expected to reach materials volumes of 30 million tons and sales of 65 billion dollars by the year 2020.

Technology Overview: Polymer ALD™ provides significant advantages over more conventional polymer coating technologies. The films grown are conformal to the substrate, the method is line-of-sight independent, and the films are very strongly adhered to the surface. Additionally, there is evidence suggesting that films deposited by Polymer ALD™ are flexible. This is likely because Polymer ALD™ can deposit films with thicknesses on the nanometer scale. Alumina can be deposited at temperatures as low as 33° C, making it very compatible with coating polymer substrates. The TEM image at right is a proof-of-concept alumina film on LDPE particles. This film is approximately 20 nm thick, is strongly adhered to the substrate particle, and follows the contours of the particle. This coating technique is very general on polymers and has been demonstrated on PE, PP, PET, PVC, PMMA, SiLK™ (Dow).



Furthermore, this technique is applicable to both particles and flat surfaces. A cross-sectional TEM of an alumina film on SiLK™ is shown below. Note that the SiLK™ is labeled C in the image. The alumina was grown very thick for imaging purposes. Layers as thin as 2 nm have been deposited on polymeric substrates. The Al_2O_3 layer actually smoothed the surface of this high-k dielectric polymer. This demonstrates the uniformity of the alumina coating. These films are well adhered to the polymeric substrate. Additional evidence indicates that these thin films maintain their crack-free, dense film integrity during flexing and bending on these polymeric materials.