Nanoscale transparent barrier layers for technical applications

S. Amberg-Schwab and U. Weber
Fraunhofer-Institut für Silicatforschung, 97082 Würzburg, Germany

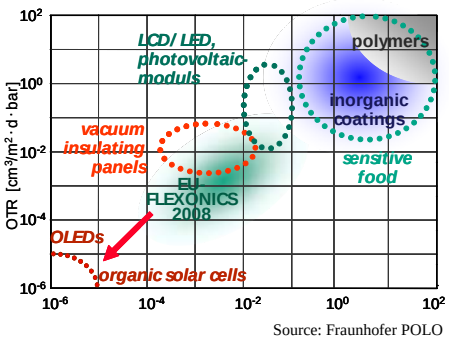
Session: Flexible substrates & encapsulation methods & materials
Contribution: Oral

Introduction: Flexible films with high barrier properties are currently in the focus for applications in an increasing number of technical fields such as encapsulation of electronic and optical devices. Polymer films show high flexibility, but usually have undesirable high permeation values. The required oxygen and water vapor barriers are orders of magnitude beyond what can be achieved by current state-of-the-art industrial polymer technology (Fig. 1). Low permeable polymer systems are already achieved by using thin inorganic oxidic coatings by vapor-deposition methods. For very demanding applications like the encapsulation of organic solar cells or organic light emitting diodes, their permeability is still too high. In order to achieve better barrier performance, new multilayer systems are under investigation. One possibility is the use of nanoscaled hybrid inorganic-organic polymers (ORMOCER®s), which are processed by wet chemical techniques like sol-gel-processing in combination with vapor borne inorganic thin films.

Experimental Details: The properties of hybrid polymers can be controlled on a molecular scale between more inorganic glass like and highly flexible polymer like (Fig. 2). ORMOCER®s show high transparency due to the nanoscaled building blocks of their constituents. The inorganic units of the hybrid polymers are generated by an in-situ method. For a further improvement and optimization of the layer properties, it is also possible to use nanoparticles in the hybrid sols. Another possibility to improve the barrier properties is the incorporation of active compounds to react with oxygen and water vapor (scavengers). This work is part of actual projects.
The use of hybrid polymers as transparent barrier coatings for various polymer substrates has been investigated in recent years and promising results could be achieved. Multilayers based on inorganic oxidic (AlO_x, SiO_x) vapor deposited (evaporation, sputtering etc.) coatings in combination with thin hybrid polymer coatings (< 2 µm) deposited by lacquering techniques were prepared on flexible polymer substrates like PET.

Results and Potential: With this kind of barrier coating materials, namely hybrid polymers, it is possible to obtain excellent barrier properties against oxygen and water vapor. If low permeation values are needed, hybrid polymers will be combined with transparent inorganic barrier layers like SiO_x or AlO_x in sandwich structures on top of polymer substrates (Fig 3). This combination of barrier layers is very effective and leads to permeation values for oxygen and water vapor below 10^{-3} $cm^3/m^2 \cdot d \cdot bar$ or $g/m^2 \cdot d$ (Fig. 1). The multilayer EU FLEXONICS 2008 is based on PET/SiO_x/hybrid polymer which shows the best values so far. The feasible application of economic roll-to-roll processes is a key requirement for any later large-scale application.

Conclusions: This approach makes these multilayer laminates promising candidates for special applications in sophisticated technical areas. The technology seems promising enough to reach the required extremely low permeation values necessary for the application of flexible polymer films for OLEDs and organic solar cells.



Source: Fraunhofer POLO

Fig. 1: Barrier properties of polymers and coating systems (shaded areas), barrier level demanded by product applications (dotted lines).

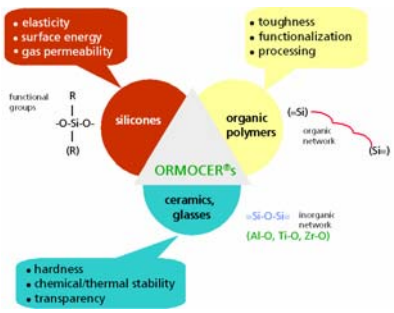


Fig. 2: ORMOCERs: Combining structures/properties of inorganic and organic polymers at the nanoscale

Fig. 3: Multilayer approach with thin inorganic layers and hybrid polymer on the substrate film for high barrier applications