Silicon oxide permeation barrier coating of PET bottles and foils deposited by hexamethyldisiloxan-oxygen plasmas

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1. Introduction

Modern packaging materials such as polyethylene terephthalate (PET) offer various advantages over glass or metal containers and are gaining in importance for food and beverage packaging. PET bottles are non-breakable and light weight compared to established materials, but they only offer poor barrier properties against gas permeation. Therefore, the shelf live of packaged food is reduced.

A plasma based processes to decrease the permeation of gases through PET foils or bottles by depositing transparent plasma polymerized silicon oxide (SiO_x) coatings is developed. The influences of gas phase composition and power conditions on chemical composition of the coating are discussed. Good barrier coatings are achieved by selecting a gas composition for the deposition of inorganic films.

2. Experimental setup

For the permeation barrier coating of PET bottles and foils, a microwave driven low pressure plasma reactor is developed [1]. Figure 1 shows the vacuum chamber with a volume of 6 liter being capable to treat various bottle sizes up to 1.5 liter and PET foils by means of a foil carrier. The reactor chamber can be evacuated to a base pressure of 1 Pa. Microwave power is applied to the system by a modified Plasmaline antenna.

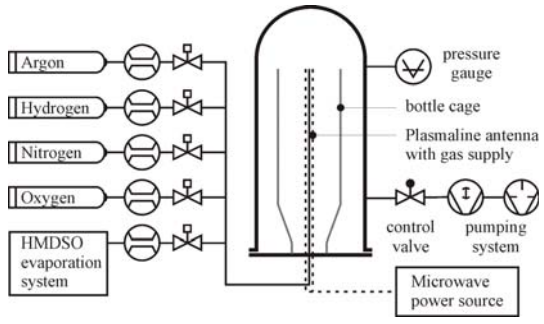

Fig.1: Experimental setup for plasma treatment of PET bottles.

As process gases, nitrogen, hydrogen, oxygen and hexamethyldisiloxane (HMDSO) can be used. For the deposition of barrier coatings liquid HMDSO is evaporated and fed into the chamber together with oxygen. A microwave source provides microwave power (f = 2.45 GHz) with a maximum of P_{cw} = 2 kW.

Silicon oxide films are deposited on PET foils as a permeation barrier coating. Therefore, a pulsed hexamethyldisiloxane-oxygen plasma is ignited under various conditions and the oxygen permeation is investigated. The optimized deposition parameters are adapted for the treatment of three dimensional bottles.

3. Results

A criterion for the homogeneous deposition of SiO_x coatings is described depending on the residence time of process gases. Additionally, the composition of the coatings is analyzed by means of Fourier transform infrared spectroscopy (FTIR) regarding carbon and hydrogen content. A strong relation between barrier properties and film composition is found: good oxygen barriers are observed as carbon content is reduced and films be-come quartz-like. Atomic oxygen etching of the coated substrate visualizes coating defects responsible for a residual permeation [2].

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