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A preparation of polyethylene coatings by pulse laser-assisted electron beam deposition

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ABSTRACT

Polyethylene (PE) coatings were prepared by a method of pulse laser-assisted electron beam deposition, using low-density polyethylene as evaporated target, silicon wafer and polytetrafluoroethylene (PTFE) sublayer as substrates. The as-deposited PE coatings were characterized by attenuated total reflectance-Fourier transform infrared spectroscopy (ATR-FTIR) and atomic force microscope. Significant crystallinity increase and root mean square (RMS) roughness decrease of PE coatings were observed in the presence of PTFE sublayer. Laser-assisted deposition increased the crystallinity and mean particle diameter of PE coatings and remarkably, the obtained PE coatings had a relative uniform particle size. These results suggested that pulse laser and PTFE sublayer might contribute to the synthesis of polymer coatings with suitable crystallinity and uniform surface structure.

1. Introduction

Polyethylene (PE) coatings have a wide range of applications in many fields, such as engineering and electronic industries, optical and biomedical materials due to its low friction, high transparence, excellent electrical insulation and hydrophobic properties [1–4]. As a semi-crystalline polymer, the applications of PE coatings are depended on their structures and morphologies that are seriously associated with preparation methods. Recently, a variety of techniques are available to coat polymers such as blown [5], extrusion method [6], sol-gel [7], vacuum evaporation [8,9] and sputtering technique [10].

Among vacuum evaporation technique, electron beam deposition (EBD) and pulse laser deposition (PLD) are very popularly for the fabrication of ultra-thin polymer coatings. They largely compete with techniques that require dissolution of polymers in solvents, as the solvent-based technique is difficult to control the coating thickness and morphology. Electron beam with a suitable energy of 1–2 keV is used as the heating source and can prepare polymer coatings with ordered structures at a high deposition rate [8]. However, primary electron generated by electron gun and secondary electron from target material will impact on uniformity of coatings in the morphology and component. For the PLD technique, the laser beam with high energy focuses on target surface and instantaneously generates high temperature plasma ($\geq 10^4$ K) on that area irradiated by the laser focused spot. This particularly facilitates the case where the polymer is intractable and cannot be processed by conventional thermal or solution method [11,12]. Under optimal conditions coatings obtained by PLD method show a high quality surface structure, even for complex chemical systems. Theoretically pulse laser-assisted EBD deposition can improve the coatings surface quality. To our knowledge, there are few work reported on the method of electron beam deposition in combination with pulse laser.

In this work we attempt to fabricate PE coatings using pulse laser-assisted electron beam deposition technique. The effect of pulse laser and PTFE sublayer on crystallinity and morphology of PE coatings will be discussed in detail.

2. Experimental

PE coatings were prepared by using a self-designed electron beam deposition device, as shown in Fig. 1. The working voltage and current density of electron beam was 1.2 kV and 0.02 A/cm^2, respectively. A LS-2137U Nd:YAG laser was performed as an assisted evaporation source with a wavelength of 532 nm, a pulse width of 7 ns and energy density of 7.18×10^7 J/s. The low-density polyethylene (LDPE, 0.92 g/cm^3) powders were used as initial target materials. The working pressure was 4×10^{-2} Pa. The deposited rate and the thickness of PE coatings were on-line monitored with a

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