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ScienceDirect
Thin Solid Films 516 (2008) 3684–3689
www.elsevier.com/locate/tsf

Development of split gliding arc for surface treatment of conductive material

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Available online 19 August 2007

Abstract

A gliding arc is one of the atmospheric-pressure plasmas and available for surface treatment. However, when this gliding arc is used to irradiate conductive materials, arc spots appear on the surface and seriously damage it. In the present study, in order to prevent such arc spot damage on a conductive substrate, a split gliding arc was designed with a multi-hole plate placed at the exit window. This split gliding arc was irradiated onto several metals, and its ability to treat the hydrophilic property was verified.

Keywords: Split gliding arc; Surface treatment; Conductive materials; Arc spot damage

1. Introduction

Plasma treatment under atmospheric pressure [1,2] is considered to be an attractive process compared to the conventional wet or vacuum process, from the standpoint of simple equipment, easy operation, low running cost, high industrial productivity, and no waste emission. When a plasma is used to irradiate a solid surface such as polymer, glass or metal, the organic contamination on the surface can be removed, the functional groups such as hydroxyl group and carboxyl group can be formed on the surface, and the surface can be etched, by chemical and/or physical reaction. As a result, a hydrophilic property can be given to the surface. For this treatment, many kinds of atmospheric plasmas (glow discharge, arc discharge, RF discharge, microwave discharge, and dielectric discharge) have been used [3–5]. Most of the plasmas require relatively expensive helium or argon as a plasma-working gas in order to obtain stable plasma. The authors have been interested in pulsed arc-discharge plasma under atmospheric pressure, since the plasma can use any gas as a working gas, even air. A pulsed-arc plasma under atmospheric pressure generates radicals as conventional cold plasma and also generates median temperatures such as room temperature up to 500 °C. We named this kind of plasma meso-plasma; the temperature ranges between those of cold and thermal plasma. The conventional gliding arc is one of them [6,7]. Some of the authors have developed another type of meso-plasma called PEN-Jet (Plasma Energized-Jet) [8,9], a new technique to generate multiple meso-plasma with only one power supply [10].

The gliding arc is considered to have better performance than the PEN-Jet for large-area treatment. The PEN-Jet is a line plasma-jet spouting from a small hole (typically less than 3 mm in diameter). The gliding arc is also a jet-type plasma, but exits from a rectangular window. Thus, it is a pseudo-plane plasma jet. However, the gliding arc has a problem in that the conductive surface suffers damage due to arc spots generated on the surface. Because of this problem, application of the gliding arc has been limited to the treatment of non-conductive material or only conductive material that permits such damage with no resultant hindrance. In order to realize damage-free treatment of conductive materials while maintaining the advantage of large-

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doi:10.1016/j.tsf.2007.08.047