FORMATION AND EVOLUTION OF THE GLOW-LIKE DIELECTRIC BARRIER DISCHARGE AT ATMOSPHERIC PRESSURE

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Abstract. Time resolved process of formation and evolution of the atmospheric pressure glow discharge was studied in the roll-to- roll plasma- enhanced chemical vapor deposition dielectric barrier discharge reactor operating in helium-free gas mixtures by means of fast ICCD imaging. It was observed that the discharge gradually experiences Townsend-like, transient positive streamer and expanding glow phases.

1. INTRODUCTION

Atmospheric Pressure Plasma Enhanced Chemical Vapor Deposition (AP PECVD) of thin films is a recently emerged technology, showing important advantages in comparison with the traditional and well established low pressure plasma enhanced deposition methods. The main benefit of AP-PECVD is the potential of cost efficient in-line production without expensive and bulky vacuum equipment. However, the ignition and sustaining of the high power uniform non-thermal atmospheric discharge, which is required for any generic surface treatment, imposes serious scientific and technological challenges.

One of the ways to produce stable non-thermal atmospheric plasmas, allowing direct uniform treatment of the large surface areas, is the dielectric barrier discharge (DBD). When compared to other promising atmospheric plasma sources, e.g. corona discharge or atmospheric pressure plasma jets (APPJ), the DBD is characterized by low gas consumption, considerable specific power deposition and potential for size scaling. Unfortunately, the most common form of high-pressure dielectric barrier discharge is non-uniform and filamentary. The existence of the uniform diffuse modes of DBD (suitable for high pressure PECVD) is usually strongly limited by the use of a specific gas mixture composition, dissipated power, operation frequency etc. Two different types of diffuse atmospheric dielectric barrier discharges are presently in focus and of significant research interest: the low current atmospheric pressure Townsend-like discharge (APTD) and high current atmospheric pressure glow-like discharge (APGD) [1-4]. The typical current densities for APTD are in the range of 0.5 mA/cm^2, while for the APGD current densities are ~ 100 mA/cm^2. APGD is providing higher dissipated specific power densities comparing to APTD, thus, being more compatible with plasma enhanced high rate deposition processes.

The physical mechanisms leading to the formation of the desirable diffusive discharge modes are still a subject of scientific discussion. It is argued that uniform APGD is produced by superposition of large number of streamers, or, alternatively, discharge appears as one large diffusive current spot. While several time- resolved experimental investigations of the APGD formation and evolution were already reported for pure helium [5,6], the present contribution reports on the study of the glow-like discharge development in an operating roll-to-roll AP-PECVD reactor [3] utilized for deposition of thin silica-like films in He-free gas mixtures.

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