Emergence of a substrate-temperature-dependent dielectric process in a prototypical vapor deposited hole-transport glass

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Abstract

Glasses are object of an intense research due to its importance in industrial applications. In particular, electronic industry has exploited the ease of producing large areas of glassy films with macroscopic homogeneity, extensively using glasses in organic electronic or photovoltaic devices. Vapor deposition, typically used to prepare amorphous organic devices, has recently emerged as a relevant tool to further understand the nature of glasses thanks to the discovery of glasses with unprecedented density levels and tunable molecular orientation, which depends on the deposition conditions. Molecular orientation is, in fact, one crucial parameter in the field of organic electronics, since the charge transport properties of a device or the output efficiency of an OLED can be drastically improved in more ordered structures. Dielectric spectroscopy, on the other hand, is a basic technique to study the properties of glasses at a molecular level, probing the dynamics of dipoles or charge carriers. Here, and for the first time, we explore the dielectric behavior of vapor deposited N,N-Diphenyl-N,N'bis(methylphenyl)-1,1'-biphenyl-4,4'-diamines (TPD), a prototypical hole-transport material, prepared at different deposition temperatures. We report the emergence of a new relaxation process which is not present in the ordinary glass. We associate this process to the Maxwell-Wagner polarization observed in heterogeneous systems, and induced by the enhanced mobility of charge carriers in the more ordered vapor deposited glasses. Furthermore, the associated activation energy establishes a clear distinction between two families of glasses, depending on the selected substrate-temperature range. This finding positions dielectric spectroscopy as a unique tool to investigate the structural and electronic properties of charge transport materials and remarks the importance of controlling the deposition conditions, historically forgotten in the preparation of optoelectronic devices.

Keywords: organic glass, ultrastable glass, vapor deposition, molecular orientation, conductivity, organic electronics, dielectric spectroscopy, maxwell, wagner.

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