Search for a wetting layer in thin film growth of para-hexaphenyl on KCl(001)

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Abstract

The non-existence of a strongly bound wetting layer for the system para-hexaphenyl (6P)-KCl(001) was verified by thermal desorption spectroscopy (TDS) and X-ray photoelectron spectroscopy (XPS). The 6P films were grown by physical vapour deposition under ultrahigh vacuum conditions at 400 K. TDS showed just a single desorption peak even down to a coverage of 0.1 nm mean film thickness. The heat of evaporation for 6P was determined to 2.3 eV. From the change of the XPS K2p substrate signal as a function of the mean film thickness one can conclude that a strong de-wetting exists at the very beginning of the 6P layer growth at 400 K. Additional investigations with atomic force microscopy reveal that at this initial stage the film grows in a form of needle like islands with a high aspect ratio and subsequently terraced mounds of 6P are formed. No dissociation of 6P on KCl was observed.

Keywords: Hexaphenyl; Potassium chloride; KCl(001); Film growth; Wetting layer

1. Introduction

Thin films of para-hexaphenyl (6P) have attained considerable interest in the recent past, due to their excellent luminescence properties in the blue visible region. Successful applications of this material for light emitting diodes [1,2], field effect transistors [3], photovoltaic elements [4] and nonlinear optics [5] have been reported. In this context the morphology of the 6P films and the particular properties of the interface between the substrate and the film are of utmost importance. It is well known that 6P films can either grow in the form of needle like islands, where the molecules are oriented with their long axes parallel to the substrate, or in form of terrace like islands where the molecules are oriented upright [6]. The development of these film structures depends on the type of the substrate, the substrate structure and the chemical composition of the substrate. In addition, very often the first layer of the film is more strongly bound to the substrate than the subsequent layers. This special first layer is called the wetting layer. Such a wetting layer plays a dominant role for the thin film growth and may also largely determine the electronic properties of electronic devices. Since this monomolecular layer is not easily detectable with techniques usually applied in thin film technology [atomic force microscopy (AFM), X-ray diffraction (XRD), transmission electron microscopy (TEM)], the existence of such a layer has often been the subject of controversial discussions.

Potassium chloride (KCl) is frequently used as a substrate to study the thin film morphology of 6P. Films have been grown by physical vapour deposition [1,7–12] and by hot wall epitaxy [13–15]. It has been observed by AFM that the grown films consist of needles and terraced mounds. In some recent works it was proposed from phase imaging AFM [15] and from XRD investigations [13] that both needles and terraced mounds grow directly on the substrate surface, without a wetting layer. However, no direct proof could be given. In this letter we address the question of a wetting layer by combined X-ray photoelectron spectroscopy (XPS) and thermal desorption spectroscopy (TDS) studies under well defined ultrahigh vacuum (UHV) conditions,