THE ROLE OF HUMID AIR ANNEALING ON THE EMISSION STABILITY OF Alq_3

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8-hydroxyquinoline metal chelate complexes were used in the past by chemists for gravimetric determination of various metal cations in solutions [1], but their use subsided in time with the advent of new spectroscopic techniques. More recently, the discovery of efficient electroluminescent devices based on tris(8-hydroxyquinoline)aluminum, Alq_3, attracted renewed interest in this class of materials to be utilized as optically active media in organic light-emitting diodes (OLED) [2]. Nowadays, this area of research is currently in a period of rapid growth with many industrial and academic groups from all over the world already running active research programs. However, there are still consistent obstacles on the road to full commercial production [3]. Indeed, polymers and organic compounds used in the OLED layers are sensitive to oxygen and moisture [4], and degradation processes have also been attributed to various mechanisms, including crystallization of the emitting layers, electrochemical reactions at the electrode/organic interface, migration of ionic species, and electrochemical reactions [5].

Recently, it has been further confirmed with simple annealing experiments that Alq_3 films are highly susceptible to humidified atmospheres, and especially air [6,7]. Figure 1 shows the normalized photoluminescence intensity of two films kept for 10 min at different temperatures up to 250 °C in ambient and humidified air. The films, obtained by evaporation under vacuum on glass substrates, have been excited at 395 nm and the emission intensity measured at RT at about 525 nm. A log scale for the intensity was used to accommodate the data spanning four decades. The abrupt emission decrease above ~175 °C of both samples has been attributed to the physical destruction of the film itself due to a reaction of Alq_3 with water contained in air [4,6,7], while the substantial and unexpected emission increase of the film annealed in humidified air before the previous decreasing represents a new phenomenon. In order to clarify it, a new film has been annealed in humidified air at 150 °C and the emission measured afterwards in air at RT as a function of time. Firstly, the annealing treatment increased the emission by 45% with respect to the initial value, and the temporal behavior of the emission after the thermal treatment is reported in Fig. 2. The emission intensity vs time is remarkably stable, especially when compared with that of a just evaporated film which during the same time span decrease by 40% at least. It is evident that the process of annealing in humid air is producing a new phase for the Alq_3 in the film. Different phases have already been observed [8], and the previous one could also coincide with one of them, but here the stability of this new phase in air has been disclosed for the first time. This result possesses important implications both for the development of environmentally stable OLED devices and for basic understanding of the morphological structure of Alq_3 systems.

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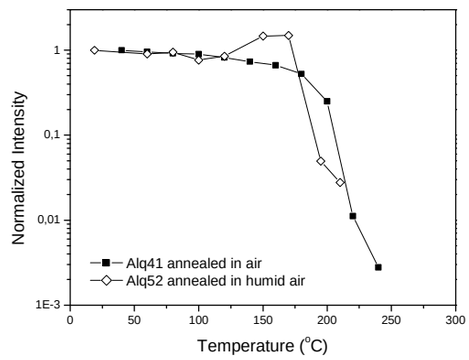

Fig. 1 Photoluminescence of two Alq_3 films annealed for 10 min. at each given temperature in ambient and humidified atmospheres. Samples alq41 and alq52 are 130 and 110 nm thick, respectively.

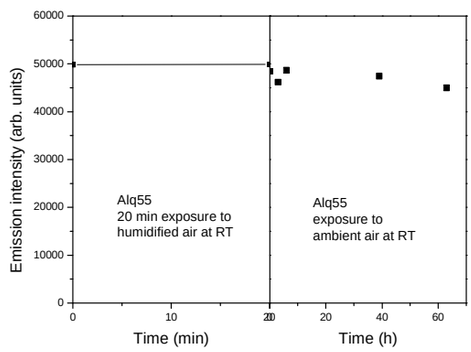

Fig. 2. Photoluminescence of the 40 nm thick film alq55, previously annealed for 10 min at 150 °C in humidified air, measured as a function of time in different atmospheres.