Advances in High TG Hole Transporters

***Olaf Gelsen*, V. Lischewski, J. Leonhardt**
Sensient Imaging Technologies GmbH, Wolfen, Germany
Phone: +49-3494-636963, E-mail: Olaf.Gelsen@eu.sensient-tech.com

Abstract

The glass transition behavior of OLED materials is very important for both processing and lifetime. We report about the correlation between the structure of selected small molecule Hole Transport Materials (HTM's) and their glass transition temperature. The thermal stability of devices manufactured with them was investigated. The results give researchers and engineers some information which are helpful for designing new molecules and processing them in device making.

We have modified known relevant HTM or synthesized literature known ones by

- introduction of bridges in order to make structure more rigid
- symmetric or asymmetric introduction of bulky substituents
- oligomerisation of triphenylamine units

The results show that the substituents in a qualitatively foreseeable manner influence the T_g-values.Our experiments indicate, that there is a fairly specific effect on the T_g-value for each class of compound and each structural change.

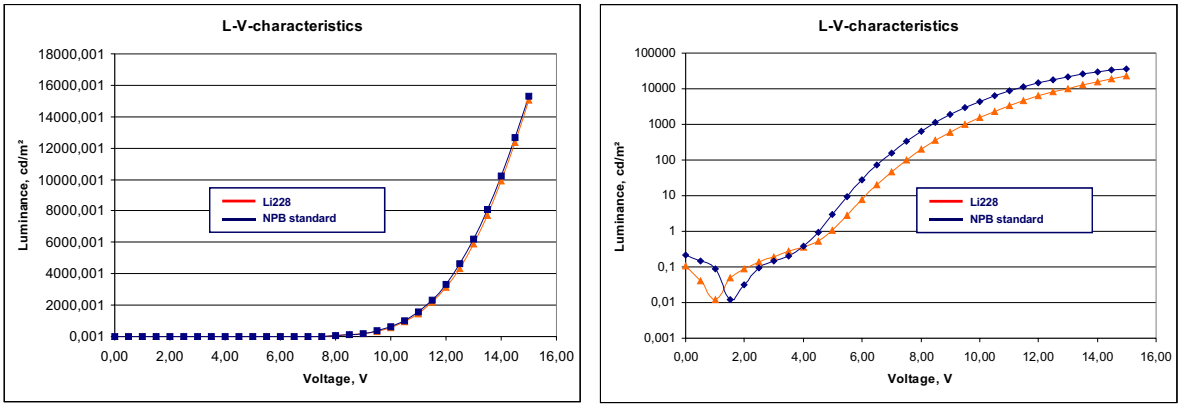
Table 1: Shift in glass temperatures caused by molecular changes

structural change	**T_g-shift**
Dimers → Tetramers	+ 55 ... + 70 °
Introduction of biphenylyl groups	+ 3 ... + 20 °
Introduction of triphenyl-methylphenyl groups	+ 55 ... + 70 °
Change from triphenyl-methylphenyl to triphenyl-silylphenyl	+ 5 ... – 9 °
Bridging of biphenylen group (centerpiece and/or wing group)	+ 4 ... + 16 °
Introduction of hexaphenylbenzene group	+ 27 ... < 180°

An OLED consists of a stack of very thin layers of mostly organic compounds. The thickness varies from 1 to some 100 nm depending on the function in the device. There are a lot of requirements which decide whether a material is suitable or not, but the morphologic stability of the layers is one of the most important ones. Recrystallisation is estimated to be one of the crucial reasons for devices showing decreasing luminance, lower luminous efficiency, dark spots or finally complete device failure. It is one of the goals chemists have when they design new OLED molecules to reduce recrystallisation by increasing the Glass-Transition temperature [1].

In our work we found a number of compounds having high and very high T_g's but poor operational device lifetimes. We believe the reason is, that most of of these moleculus have a very large and branched molecular structure with predetermined "chemical" breaking points within this structure and for this reason they cannot withstand the electrical stress during their working life.
Thus we focused our further works onto molecules having a compact bulky structure, high internal stiffness and the absence of breaking points.

These activities resulted in some High T_g HTM's, very suitable for application in OLED devices.



Figur 1: L-V-characteristics of Li228 and α-NPB

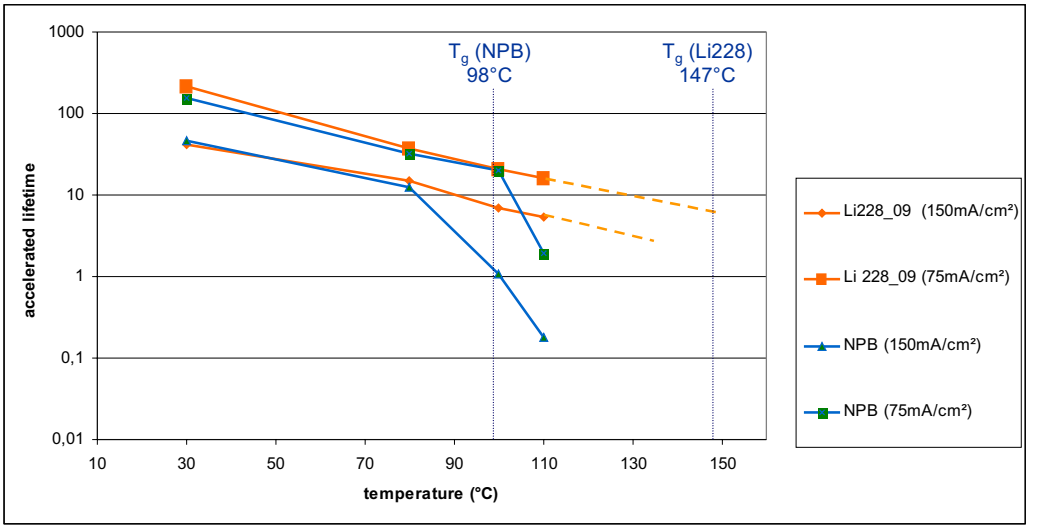


Figure 2: Widening the operational temperature window using High T_g materials

As an example we present some data of our High-T_g HTM Li228. This compound shows the same OLED performance data like the commercial α-NPB, but compared with α-NPB (T_g = 98°C) it has a significantly enhanced glass transition temperature of 147°C.

The most important advantage of a high T_g is that such a compound can widen the operational temperature window of an OLED device.
As shown in figure 2, a device containing α-NPB as hole transporter undergoes a significant decay in lifetime if its working temperature exceeds the glass transition temperature of about 98°C. In case of our high T_g material no accelerated decay in lifetime can be observed even at temperatures higher than 100°C.

Hence, with these materials we can fulfill the demands of working temperatures of 120°C and above, arising for example from the automotive industry and other application fields.

Ref.:

[1] *Tamano, M., Onikubo, T., Okutso, S., Enokida, T.,, EP 8485579, Toyo Ink Manufacturing Co. Ltd.*