

# STUDY OF ORGANIC SEMICONDUCTOR H2T26N BY RAMAN SPECTROSCOPY

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## 1. Introduction

Over the past decade, the number of research groups exploring the field of organic electronics has exploded due to the potential use of organic semiconducting materials as a low-cost alternative to silicon. Applications for organic semiconductors include organic thin film transistors (OTFTs), light-emitting diodes (OLEDs), photovoltaic cells, sensors, and radio frequency identification (RF-ID) tags for integration into low-cost, large-area electronics. The main advantages of using organic materials lie in the cost and processibility. One of the most wide-spread organic semiconductors is pentacene, which has recently gained the most interest for its high carrier mobility around of  $1\text{cm}^2/\text{Vs}$  [1, 2]. Deposition of this organic semiconductor is realised mostly by evaporation in a high vacuum. On the other hand, solution-based processing has been envisioned for low-cost and large area applications, provided that the electrical properties reach the needed level of mobility [3].

In our paper we report the Raman study of new organic semiconductor material, H2T26N. The films were fabricated by solution-processing on Si- substrates. We show first time Raman spectrum of this new material obtained on large crystals. Measured spectra taken from 100 nm thin layer are sufficient intensive for identification of this material in the prepared structures.

## 2. Experimental details

Organic oligomer 2,6-bis(5'-hexyl-2,2'-bithiophen-5-yl)naphthalene ( $\text{C}_{38}\text{H}_{40}\text{S}_4$ ) called as H2T26N, depicted in Fig. 1, has been synthesized in laboratory of Comenius University. Powder of this oligomer was dissolved in toluene on the temperature of  $110^\circ\text{C}$  and then organic layer was prepared by tilt-casting, where the Si-substrates were kept on the temperature specific temperature defined by the hot plate. The solution was dropped from the heated pipette on the bare glass substrates and the excess solution was removed by the substrate tilting with keeping the substrate temperature. The whole organic layer deposition was performed under the nitrogen atmosphere. Three different samples have been investigated. Temperature of substrate at films deposition was 105, 110 and  $120^\circ\text{C}$ . The average organic film thicknesses of samples were 100 nm. We expect the utilization of these films to the fabrication of organic field-effect transistors.

A Jobin Yvon HR800 monochromator equipped with a CCD detector was used to record the micro-Raman and photoluminescence spectra at room temperature in backscattering geometry. The spectra were excited with a He-Ne laser (633 nm line). The incident laser beam was focused by microscope lens to a spot size diameter of  $1.3\ \mu\text{m}$ .

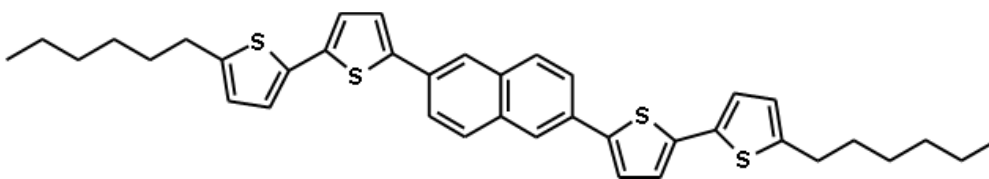


Fig.1: Molecular structure of H2T26N.

### 3. Results and discussion.

In Fig. 2 we see surface morphology of prepared structure observed by optical microscopy. Besides of nearly uniform surface, presented in Fig. 2a, we have sometimes observed small or also big grains (Fig. 2b). Typical spectra taken from big grain are depicted in Fig.3.

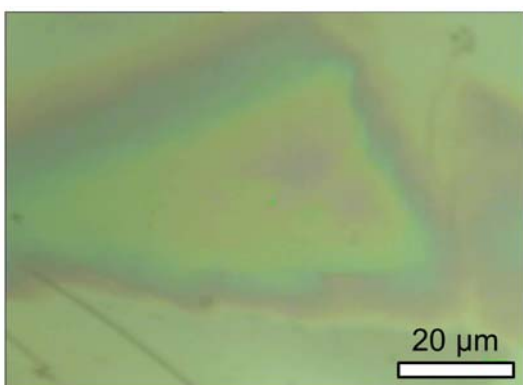


Fig.2a: Surface of the film observed by optical microscopy.



Fig.2b: Big grain on the surface of the film.

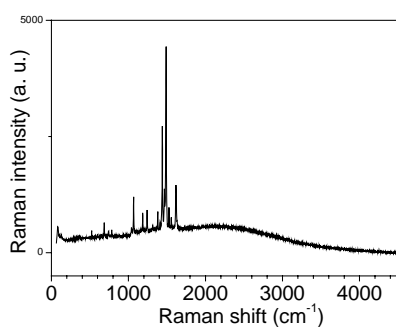


Fig.3a: Typical Raman spectrum taken from big grain.

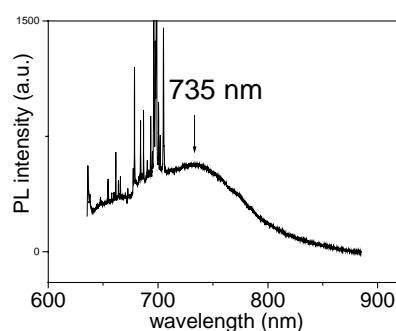


Fig.3b: Photoluminescence spectrum converted from Raman spectrum (to nm – scale on x-axis).

From Fig.3a we can deduce, that active Raman peaks are between 80 and 1700  $\text{cm}^{-1}$ . Maximum of photoluminescence is at the value of 735 nm, as it is possible to see from Fig. 3b. All Raman peaks in magnification we see in Fig.4. It is the first time published Raman

spectrum of H2T26N with correct determination of frequency positions of Raman peaks. From earlier study of other organic semiconductors is known [4] that the Raman peaks in frequency range around  $1150\text{ cm}^{-1}$  are due to C-H in plane bending and the around  $1350\text{ cm}^{-1}$  is due to C-C aromatic stretching modes of molecules. In the future we will concentrate to the influence of technological condition on the intensity and forms of Raman peaks in these two ranges.

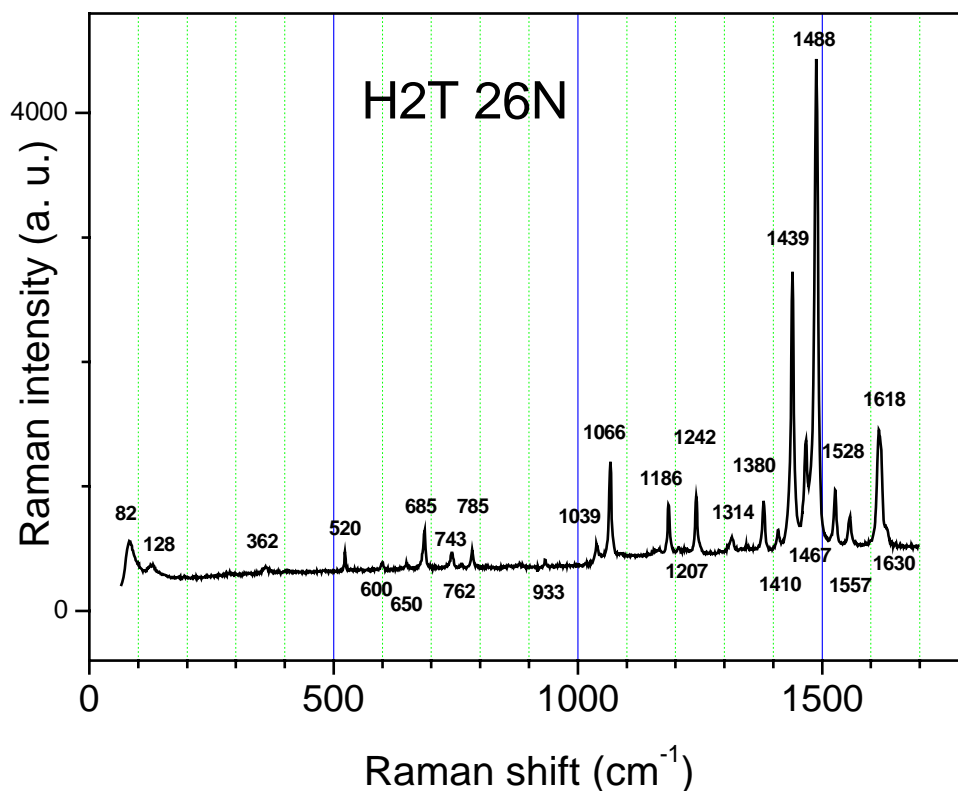


Fig.4: Detailed Raman spectrum taken from big grain of H2T26N.

Identification of thin films of H2T26N is a little complicated. At very thin films, with the thickness of few nm we have obtained low intensity of photoluminescence with its maximum at wavelength of  $\sim 740\text{ nm}$  (Fig. 5, bottom spectrum). This value is much closer to that observed at big grain of H2T26N and therefore it is a direct evidence of the substrate thin film coverage by organic material. Due to a low intensity of scattered light it was not possible to detect Raman peaks.

At thicker films ( $\sim 100\text{ nm}$ ) we have observed besides photoluminescence also Raman peaks (Fig. 5–top spectrum). The observed peaks are identical with those ones observed at bulk material of H2T26N (big grains). Measured Raman spectrum clearly confirms presence of H2T26N in the studied film. From decrease of intensity of Si peak in our films we have roughly estimated penetration depth in studied oligomer as high as  $400\text{ nm}$ .

#### 4. Conclusion

We have studied thin films of H2T26N by using of Raman spectroscopy. On thick layer and more precisely on big grains of this organic semiconductor material we have

observed and estimated frequency positions of Raman peaks, first time in this studied material. In the case of very thin films, with a thickness of few nm the Raman peaks are very low intensity and they are not detectable. Presence of H2T26N material in these types of films is confirmed by photoluminescence spectrum with its maximum at wavelength of 735-750 nm. Penetration depth of used 633 nm laser-line was experimentally estimated as 400 nm.

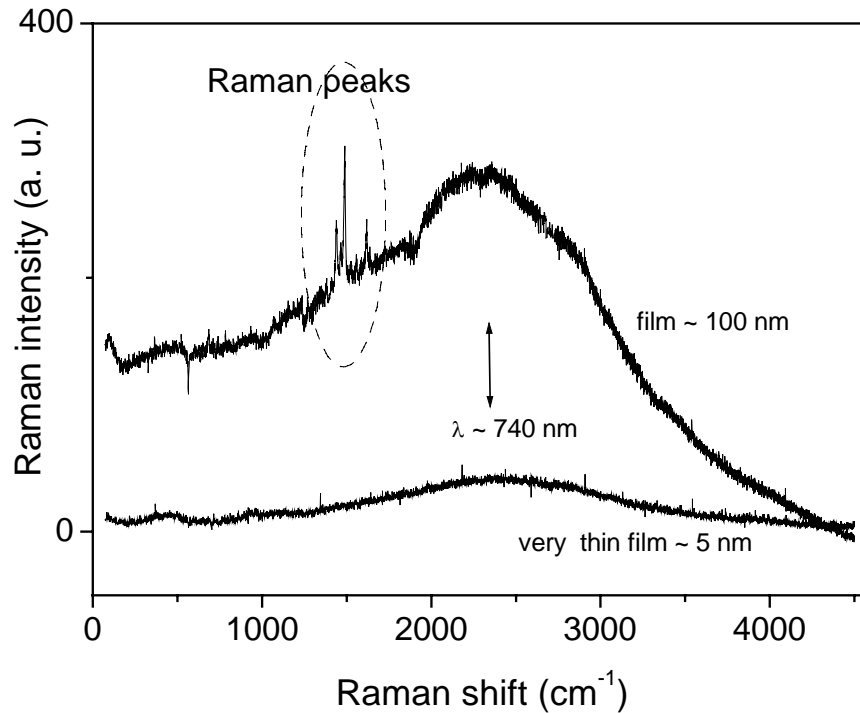


Fig.5: Raman spectra of H2T26N observed at very thin film (bottom spectrum) and at 100 nm- thick film (top spectrum).

### Acknowledgement

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