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Thesis outline

The title of the thesis work is "Preparation of Thin Carbon Film for Liquid Crystal Alignment by Plasma Processing" and it consists of 5 chapters. In the following text more details are presented for each chapter.

Chapter 1. "Introduction"**.** A general introduction was given about the basics of liquid crystals (LC), LC alignment layer and some fundamental aspects of plasma systems. Basic physical characteristics of liquid crystals were explained, as well as different types of LCD, operation principles and structures. Alignment layer functionality and required physico-chemical properties were discussed, as well as conventional and alternative techniques for LC alignment layer fabrication. A general introduction into plasma physics was given, with some detailed explanation on low pressure capacitively coupled plasma and atmospheric pressure plasma jet systems, used in the research work.

Chapter 2. "Atmospheric pressure plasma jet treatment of thin film surfaces for liquid crystal alignment". The results of polyimide and hydrogenated amorphous carbon film surfaces treated by the atmospheric pressure plasma jet (APPJ) system were presented. FE SEM images were analyzed to investigate the kinetics of carbon film deposition processes in a plasma enhanced chemical vapor deposition (PECVD) reactor, as well as the etching process during the APPJ treatment. FTIR and Raman spectra were analyzed to describe surface composition changes after APPJ treatment. LC cells fabricated from APPJ treated substrates were assembled to investigate alignment layer functional properties qualitatively by polarizing optical microscopy (POM). LC alignment on the conventional polyimide film and alternative amorphous carbon films were compared, for both the conventional mechanical rubbing and the alternative APPJ treatment processes. Modifications of the APPJ system to enable carbon film deposition were discussed. Optimization of the carbon film deposition process by the APPJ system was carried out. Deposited carbon films in a one step process by the modified APPJ system were used to analyze alignment properties in POM. Comparisons between the one step and two step alignment layer fabrication methods were carried out. Alternative a-C:H films show excellent LC alignment properties after conventional mechanical treatment, and could be considered as environmentally friendly replacement for conventional polyimide films. Treated by APPJ, a-C:H and polyimide films show good alignment on the micro scale, and no artifacts

were observed, which could be seen from the conventional method, like rubbing streaks. However on a macro scale it was difficult to achieve high alignment uniformity. Deposited by APPJ, carbon films show the same optical quality as APPJ treated films. Reducing the fabrication method into one step is another of the key advantages of the proposed technique. To describe defects occurring on the surface of treated surfaces, a study on alignment mechanism is required.

Chapter 3. "Surface memory effect enhanced by plasma jet treatment". A study on the alignment mechanism of LC molecules on APPJ treated surfaces was presented in this chapter. LC alignment patterns on APPJ treated substrates at different incubation temperatures were investigated. During incubation period LC is existing in different phases (crystalline, LC, isotropic) and different patterns of alignment are imprinted onto the alignment layer. The strong surface memory effect induced by APPJ treatment on treated substrates was discussed, as well as its applications. Alignment mechanism of LC molecules on APPJ treated surfaces was proposed. Induced alignment was considered to be the result of a combination of two effects: a surface memory effect enhanced by APPJ treatment and flow alignment of LC during injection in LC phase.

Chapter 4. "One step fabrication of LC alignment layer in PECVD reactor". A study on electrode configurations in a low pressure PECVD system is presented in this chapter. The influence of ion bombardment (generated by geometric shaped electrodes) was investigated on alignment properties. Different alignment patterns on fabricated cells with different electrode configurations were presented. A new optimized reactor design was proposed to fabricate alignment layer in one step. The optimized reactor was assembled and tested for LC alignment layer fabrication. The stability of the deposited alignment layers was tested. A comparison between the conventional and alternative method was carried out. LC cells fabricated from substrates with alignment layer deposited in a low pressure PECVD reactor showed excellent alignment properties; comparable to the conventional method. As a one-step process, as well as a non-contact method, it represents as a good candidate for the replacement of the conventional mechanical rubbing technique.

Chapter 5. "Conclusions"**.** A general conclusion of the research work is given in this chapter.