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13. ABSTRACT *(Maximum 200 words)*
We demonstrated the highly oriented growth of an organic salt using the new process of low pressure organic vapor phase deposition (LP-OVPD). This follows on our earlier work in the demonstration of atmospheric pressure OVPD. In the kinetic regime of LP-OVPD, however, there is improved surface morphology and crystalline alignment, to the point that we can now routinely achieve the alignment of DAST thin films across entire wafer surfaces. The material is excellent for optical modulators. We are currently investigating a modulator design which employs titanium dioxide waveguides coated with oriented DAST films. The wave propagating in the waveguide is evanescently coupled into the organic film which can be used to shift the phase of the wave by application (through electrodes) of an electric field. One milestone for the coming year is to demonstrate low voltage DAST-based phase modulators grown using LP-OVPD. This work is being published as an invited paper in Advanced Materials.

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COVER SHEET

Program Title: Investigations of Crystalline Organic Nanostructures Grown by Ultra-High Vacuum and Vapor Phase Techniques

Grant No.: F49620-96-1-0277

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1. Current Progress and Accomplishments in FY98

This past year has been spent primarily in investigating excited states in organic thin films for use in laser and organic light emitting devices (OLEDs). We were the first group to unequivocally observe lasing action in organic semiconductor films using optical pumping techniques. This work, which included development of a fundamental understanding of the quantum nature of lasing action in doped systems was published in *Nature, Science, Journal of Applied Physics* and *Applied Physics Letters*. Two of the most interesting findings of this work were the observed temperature insensitivity of the organic laser characteristics (due to the similarity between dye doped organics and quantum dot lasers), and the very narrow spectral linewidths characteristic of organic emitters. Since those early results, we have concentrated on quantifying the nature of organic films under very high pulsed electrical injection (~300 A/cm^2) which is needed for pumping electrically excited organic laser diodes. We find that polaron absorption is a significant problem in organic thin films which may ultimately raise the threshold current of organic laser diodes to unacceptably high levels. Currently, we are concentrating on fabricating organic laser diodes employing transparent contacts for both electron and hole injection. Early results on Fabry-Perot laser structures under intense electrical pumping show a narrow spectral output but no spectral narrowing with pump intensity. We are currently investigating the source of this interesting effect.

In a parallel effort, we have demonstrated that organic *phosphors* doped into conducting hosts can lead to very high efficiency OLEDs. This is in contrast to previous work where only fluorescent emission was employed using dyes doped into conductive organic thin films. In these studies, we discovered that the red emitting organic phosphor, PtOEP, could emit with nearly 6% external efficiency when doped into the appropriate host such as carbazol biphenyl. The decay time of the emission was 30 μs, which is adequate for all display applications. Furthermore, we have used organic electrophosphorescence to investigate such fundamental processes as the singlet-to-triplet ratio in aluminum tris(8-hydroxyquinoline). This study should provide fundamental insights into spin statistics in organic molecular systems. The work has been published in *Nature* and we have submitted papers to *Physical Review Letters* and *Applied Physics Letters* on this exciting new area of research.

Finally, this year we demonstrated the highly oriented growth of an organic salt using the new process of low pressure organic vapor phase deposition (LP-OVPD). This follows on our earlier work in the demonstration of atmospheric pressure OVPD. In the kinetic regime of LP-OVPD, however, there is improved surface morphology and crystalline alignment, to the point that we can now routinely achieve the alignment of DAST thin films across entire wafer surfaces. The material is excellent for optical modulators. We are currently investigating a modulator design which employs titanium dioxide waveguides coated with oriented DAST films. The wave propagating in the waveguide is evanescently coupled into the organic film which can be used to shift the phase of the wave by application (through electrodes) of an electric field. One milestone for the coming year is to demonstrate low voltage DAST-based phase modulators grown using LP-OVPD. This work is being published as an invited paper in *Advanced Materials*.

2. Program Statistics

(1) PI: Stephen Forrest
(2) Number of post docs supported: 2 (P. E. Burrows and V. Bulovic)
(3) Number of grad students supported: 2 (M. Baldo and G. Parthasarathy)
(4) Other researchers supported: 1 Part time (M. Valenti)
(5) Number of publications in the last 12 months in refereed journals: 25
(6) Number of publications acknowledging AFOSR support: 12
(7) Awards and Honors Received by the PI:
Horace Rackham Fellowship (Physics), University of Michigan
Knoller Scholarship for Physics and Chemistry, University of Michigan
TRW Faculty Assistance Award in Electrophysics, University of Southern California
Powell Foundation New Investigator Award, University of Southern California
Fellow, IEEE
1996-1997: IEEE Distinguished Lecturer: "Organic Materials for Photonics"
1997: IEEE LEOS Ann. Mtg. Best Student Paper Award. Student: V. Bulovic, Adv.: S. Forrest
1998: Intellectual Property Owners Distinguished Inventor of the Year: "Multicolor Organic Light Emitting Devices"
1998: Thomas Alva Edison Award for innovation in emerging technology: "Multicolor Organic Light Emitting Devices"

3. Transistions

a. S. Forrest, Princeton University: b. Growth of DAST by OVPD: c. V. Ban, PD-LD, Inc., 609 924 7979: d. Optical Modulators
b. S. Forrest, Princeton University: b. Organic LED and laser technology: c. J. Brown, Universal Display Corp., 610 617 4010: d. Display and optical sensing applications