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During the course of this program, major advances have been made in our understanding of the growth and optical properties of organic nanostructures. For example, we have found that a clear indication of quasi-epitaxial growth of an organic molecule is failure of the epitaxial layer to reduce strain by the generation of defects as film thickness is increased. Furthermore, studies of the optical spectra of closely packed molecules such as PTCDA indicate that organic nanostructures (such as multiple quantum wells) can be used to change the electronic and optical properties of organic materials in much the same manner as in inorganic semiconductors. Further, we have demonstrated high efficiency organic light emitting devices, as well as the invented the process of organic vapor phase deposition (OVPD) for achieving ordered growth of organic salts for nonlinear optics applications.

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Final Technical Report

Grant Title:

INVESTIGATIONS OF THE OPTICAL AND ELECTRONIC PROPERTIES OF CRYSTALLINE ORGANIC SEMICONDUCTORS

P.I. Data

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During this 3 year program, major advances have been made in our understanding of the growth and optical properties of organic nanostructures. For example, we have found that a clear indication of quasi-epitaxial growth of an organic molecule is failure of the epitaxial layer to reduce strain by the generation of defects as film thickness is increased. Furthermore, studies of the optical spectra of closely packed molecules such as PTCDA indicate that organic nanostructures (such as multiple quantum wells) can be used to change the electronic and optical properties of organic materials in much the same manner as in inorganic semiconductors. Further, we have demonstrated high efficiency organic light emitting devices, as well as the invented the process of organic vapor phase deposition (OVPD) for achieving ordered growth of organic salts for nonlinear optics applications.

In particular, the highlights of our 3 year program are the following:

• Demonstrated quasi-epitaxial (QE) growth of organics on graphite, Au and GaAs, and a quantitative understanding of these growth mechanisms was developed.

• Full understanding of quantum confinement in molecular organics developed. The impact of this work is that we have conclusively shown that excited states in closely packed organic molecular crystals can be due to extended electronic wavefunctions, similar to the case of "delocallized" semiconductors. This provides an extremely exciting opportunity to "manipulate" the density of states in organic nanostructures (e.g. multiple quantum wells) in a manner similar to that achievable in inorganic nanostructures. For example, this work may lead to the first, practical electrically pumped organic thin film laser with low threshold current density due to the reduced density of states in an organic MQW.

• First demonstration of OVPD as a means to grow multi-component organic systems. In particular, we invented this technique to grow the highly nonlinear optical salt, DAST. This material had, to this time, never been grown in a thin film form. OVPD since its first demonstration has been extended to the successful growth of organic films used in organic light emitting diodes. To improve surface morphology of the grown films, we have also demonstrated the OVPD growth of DAST at low pressure (5 Torr). This invention has been patented and transferred to the industrial sector (PD-LD, Inc., Princeton, NJ)

• First understanding of the link between electroluminescence (EL) and current conduction in organic light emitters. This has lead to the demonstration of very high efficiency organic light emitting devices for display applications.

• Demonstrated the first, fully transparent organic LED for head-up and multicolor display applications.