Novel Optical Approaches towards Bio-Photonics and Nanomedicine.

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Outline

- Mission Statement
- Strategic Partners
- Potential Applications
- Collaboration with CBST
- Future Vision
Mission Statement

• Creating a foundation to improve the quality of life and health
• To use nanoscopic products and technology for direct therapeutic applications
• To assist in cost effective screening and treatment protocols
• To reduce the cost of conventional therapeutic approaches

Our Mantra

“Nanotechnology Renews Health”
Nanomedicine – Medicine of the future

Liposome Nanoparticle Substance Delivery System
<table>
<thead>
<tr>
<th>U.S. STRATEGIC PARTNERS</th>
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<td>CLEAR ESSENCE ONTARIO, CA</td>
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<td>APW INC. RENO, NV</td>
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<td>MAX PLANCK INSTITUTE FOR QUANTUM OPTICS (MPQ) GARCHING, GERMANY</td>
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EUV 14 nm Pulsed Laser Plasma Source

- 1064nm, 400mJ, 10ps, 10Hz
- Target (Cu)
- Zr Filter (300nm)
- ML Mirror for 13.9nm
- Probe position

Graph showing counts vs. wavelength [nm]
Capillary Beam Splitter Design

Absorbed  Glass plates  Transmitted

Based on external total reflection.

Critical angle \( \theta_c = (2\delta)^{1/2} \sim 10^{-2} \lambda \rho^{1/2} \)

For glass: \( \theta_c = 0.026* \lambda \)

\( \theta < 2^\circ \Rightarrow R > 90\% \atop \text{at } 13.9\text{nm} \)

\( R > 50\% \) up to Si K-edge at \( \sim 1840\text{eV} \atop \text{at } 1^\circ \)

\( \delta: \) real part of refractive index

\( \lambda: \) wavelength in nm

\( \rho: \) density in g/cm\(^3\)
Beam Splitter Characterization Setup

EUV Laser Plasma Source

Zr Filter (300nm)

ML Mirror for 13.9nm

Aperture 200μm

Beamsplitter

CCD Camera

Beamsplitter
Working regimes

- $T = 0.85$, $R = 0$, $\theta = 0^\circ$
- $T = 0.4$, $R = 0.4$, $\theta \sim 0.5^\circ$
- $T = 0$, $R = 0.70$, $\theta \sim 1^\circ$
Characterization of the beam splitter

T = 0.85
R = 0

T = 0.4
R = 0.4

T = 0
R = 0.7

Reflected beam

Transmitted beam

Graph showing relative intensity vs. beam splitter angle [deg] with two lines representing transmitted and reflected beams.
Design of a Single Elliptical Focussing Capillary
Focussing Capillary - Setup

Background due to direct transmission through capillary

In Focus

Low intensity in center

Out of Focus

100nm/step
Focus Size

Spot size: ~27µm
Gain: ~ 600 (for $\lambda = 13.9$ nm)

Knife Edge Data: Total counts in selected region

Focal Spot

Moved with 0.1µm step size

CCD Chip as Knife Edge

FWHM = 27µm
<table>
<thead>
<tr>
<th>Capillary Beam splitter</th>
<th>Multi-Layer Beam splitter</th>
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<tr>
<td>• High Transmission T+R ~ 80%</td>
<td>• Low Transmission T+R&lt;30%</td>
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<tr>
<td>• Variable T/R ratio</td>
<td>• Undisturbed beam profile &amp; wave front</td>
</tr>
<tr>
<td>• Wavelength independent</td>
<td>• Limited Bandwidth</td>
</tr>
<tr>
<td>• Broadband, Robust</td>
<td>• Thin Foil</td>
</tr>
<tr>
<td>• Usable for pump/probe experiments &amp; as attenuator</td>
<td>• Usable for interferometry</td>
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Focusing and Collimation of Femtosecond X-ray Pulses by Polycapillary Lenses

Experimental Setup for Fe Kα radiation at 6.4 keV. The resulting best focus shows beam waist of 86 µm and an intensity enhancement of about 1600.
Convergent-beam diffraction pattern of femtosecond x-ray pulses

Studies of Conformational Changes in Organic Crystals using Femtosecond X-ray Diffraction

Conformational changes in DMABN

Simulations (PowderCell [6]) predict enhanced 004 reflection upon rotation of the methyl-groups.

DMABN: 004 Bragg reflection

DMABN – Dimethyl amino benzo nitrile crystal
Experiments with a half-lens

a) Optical image of the exit path of the half-lens

b) CCD image of an x-ray beam from an x-ray tube collimated by means of a half-lens.

c) Beam pattern of Fe Kα radiation collimated by the half-lens.
Oblique Incidence Reflectivity Difference (OI-RD) Ellipsometry

Laser (632 nm) → Polarization Modulator → Phase Shifter → Substrate → UV/O irradiated lipid bilayer → Liquid Cell

Scanner Beam by Translating Substrate

Analyzer → Detector

Fluorescence image of a lipid bilayer sample

Chemically etched, fused with lipids and irradiated through a photo mask using UV light

Results obtained from Rajesh’s M.S Thesis in collaboration with Prof. Atul Parikh
Ellipsometric results on various lipid samples in the MIR spectral range

OTS – Octadecyl Trichloro Silane

POPC - P1-Palmitoyl-2-Oleoyl-Sn-Glycero-3-Phosphocholine

tan $\Psi$ is the Reflection Coefficient

Spectra obtained with Kollmar-MCT detector.
Ellipsometric results on various lipid samples in the MIR spectral range contd...

\[ \Delta \] is the phase shift induced by the reflection

Spectra obtained with Kollmar-MCT detector, 24x32 scans, purged.
Liposomes have a membrane structure similar to biological membranes.

The interior of a vesicle is an aqueous environment, and it is possible to prepare liposomes with different substances entrapped.
THE FUSION OF A VESICLE WITH THE PLASMA MEMBRANE OF A CELL

Model of EPL nanoparticle interacting with the cell as a drug delivery tool. For example, EDTA, Vitamin C (Ascorbic Acid), Insulin, etc. can be delivered.
Our spectroscopic products

Ultra compact Micromirror Spectrometer with Accessories for the Near Infrared (NIR) and Middle Infrared (MIR) wavelength regions

Transmittance Sample Cell with Exchangeable Cuvettes for Solid, Liquid and/or Gaseous Samples

ATR-Measuring-Probe for Absorption Measurements in Liquids or at Solids

Market Potential of NIR & MIR modules

- Patented and ultra compact design
- Portable and low cost devices
Nanolife Inc and Nanomed LLC

• Headquartered in Reno, NV
• 3.0 acres Industrial Site, Dayton Industrial Park, NV
• 6000 sq. ft. R & D facility, Conference Room
• High tech training facility
• Testing and application Laboratory

www.nanolifeinc.com
1. Nanolife is dedicated to solve mankind’s most urgent biomedical and environmental problems to improve the quality of life, human health and safety.

2. Nanolife has formed multi disciplinary teams combining skills of physical, chemical, mathematical and life scientists as well as engineers to address the nation’s pressing problems in Biophotonics, Nanomedicine and Biotechnology.

3. Our most important products (Nanoxir) are associated with liposome delivery systems.

4. Nanolife is also developing novel, portable, affordable spectroscopic detection devices at the molecular level.
CBST + Nanomed
(Bridging NV and CA)

Nanomed core group
Future Vision

• Participation of Nevada graduate students at CBST facilities.
• Establishment of joint lecture series and research facilities.
• Joint commercialization of research and technology.
Special Thanks

CBST- Center for Biophotonics Science and Technology
NSF- National Science Foundation
LLNL- Lawrence Livermore National Laboratory
UCD- University of California Davis
UNR- University of Nevada, Reno
Nanolife Inc.
Applied Photonics Worldwide (APW) Inc.
MPQ- Max Planck Institute for Quantum Optics
MBI- Max Born Institute
Special Thanks contd..

IFG- Institute for Scientific Instruments GmbH
ISAS- Institute for Analytical Sciences
TUC- Chemnitz University of Technology
Sentech Instruments GmbH
Colour Control GmbH
DAAD- German Academic Exchange Service
Ludwig- Maximilians- University of Munich
Heinrich-Heine-University of Duesseldorf