

2006 APS April Meeting

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## Sunday, April 23, 2006 8:30AM - 10:18AM –

Session H6 DPB FIAP: Applications of Free Electron Lasers I Hyatt Regency Dallas Cumberland J

**8:30AM H6.00001 Materials Processing with FEL Radiation- An Overview<sup>1</sup>** MICHAEL J. KELLEY, Thomas Jefferson National Accelerator Facility — A unique feature of FEL's is their enormously wide range of output parameters, enabling "processing by design". The FEL's energy delivery can be matched to materials properties, accomplishing the intended transformation. The immediate beneficiary is materials R&D, where systematic experimental investigations can now truly dance with computational modeling to make unique materials. For example, depositing energy into specific organic molecular bonds in a time frame too brief for escape into the rest of the molecule, results in selective bond scission. Collecting the ablated fragments on a substrate affords a molecularly faithful coating. Solvent-related complications of conventional coating are avoided, a greater advantage the wider the range of organics to be explored. Sharply adapting the FEL's design to a specific parameter set and taking advantage of the fall of unit cost with increasing power holds promise for applications in manufacturing. Several potential applications in ablative materials synthesis, rapid thermal processing and surface photochemistry will be briefly discussed.

<sup>1</sup>Work supported by U.S.Dept.of Energy DEAC05-84-ER40150, Office of Naval Research, Joint Technology Office, Commonwealth of Virginia and Jefferson Lab Laser Processing Consortium

## **9:06AM H6.00002 Infrared Pulsed Laser Deposition: Applications in Photonics and Biomedical Technologies<sup>1</sup>**

RICHARD HAGLUND, Vanderbilt University — Resonant infrared pulsed-laser deposition (RIR-PLD) shows significant promise for synthesizing thin films of small organic molecules, thermoplastic and thermosetting polymers and biopolymers, without compromising structure or functionality. This contrasts with most attempts at UV-PLD of organic materials, which have often been accompanied by severe photochemical or photothermal degradation of the ablated material. Representative recent successes in RIR-PLD include deposition of: polymers for light emission and hole transport; functionalized polymers and nanoparticles for chemical and biological sensing; and biocompatible polymers suitable for coating medical devices or drug-delivery vehicles. Plume imaging and various other optical- and mass-spectroscopy experiments appear to confirm that polymers or organic molecules ablated by resonant infrared laser irradiation experience a high spatial and temporal density of vibrational excitation, but tend to remain in the electronic ground state. The mechanism of RIR-PLD is observed to depend on the anharmonicity of the mid-infrared absorption modes, their finite relaxation time, mode-specific nonlinear absorption, and rapid changes in polymer viscosity as a function of temperature. Many of the RIR-PLD experiments to date were carried out using a tunable, mid-infrared, picosecond free-electron laser. However, if RIR-PLD is to become a practical tool for making organic thin films, it will be necessary to develop more conventional lasers that can achieve a similar combination of high pulse intensity, low pulse energy, high pulse-repetition frequency and moderate average power. In conclusion, the prospects for developing precisely such table-top RIR-PLD systems will be discussed.

<sup>1</sup>In collaboration with D. M. Bubb, N. L. Dygert, J. S. Horwitz, S. L. Johnson, M. R. Papantonakis and K. E. Schriver. Supported by the Naval Research Laboratory and the Medical Free-Electron Laser Program of the Department of Defense.

**9:42AM H6.00003 Laser Microengineering and the Advances Gained by Use of a FEL**, HENRY HELVAJIAN, The Aerospace Corporation — This abstract was not received electronically.

## Sunday, April 23, 2006 10:30AM - 12:18PM –

Session I6 DPB FIAP: Applications of Free Electron Lasers II Hyatt Regency Dallas Cumberland J

## **10:30AM I6.00001 Free Electron Laser Nitriding of Metals: From basic physics to industrial applications<sup>1</sup>**

PETER SCHAAF<sup>2</sup>, University of Goettingen, II. Institute of Physics, 37077 Goettingen, Germany — Functional or smart surfaces and coatings play an increasingly decisive role for the applicability and performance of all modern materials, and numerous methods were developed for their fabrication, stretching from simple PVD and CVD processes to complicated plasma and hybrid methods. Recently, it was established that short laser pulses of high enough energy can induce a direct laser synthesis of functional coatings if the materials surface is irradiated in a reactive atmosphere. The process is based on complicated and combined laser plasma gas material interactions. The Free Electron Laser (FEL) can be just the right tool to drive the mentioned process into the direction of industrial applicability. The high power and the flexibility in its temporal shaping of the FEL at the Jefferson Lab was the drive to make first experiments on the direct laser synthesis of functional coatings. Titanium, aluminum, silicon and steel have been treated with the FEL in pure nitrogen atmosphere at 0.1 MPa pressure. The wavelength of the irradiation was 3.1 micron with a micropulse repetition rate of 37 MHz. The micropulses were shaped to macropulses with durations ranging from 50 to 1000  $\mu$ s at 2 to 60 Hz. A meandering scanning technique was used to irradiate larger areas. The produced coatings were investigated by a number of methods (X-ray diffraction including stress and texture analysis, elemental depth profiling by resonant nuclear reaction analysis and Rutherford backscattering spectrometry, nanoindentation hardness, Scanning electron microscopy, EDX). The obtained results correlate to numerical simulations of the melt bath, diffusion and solidification dynamics. For titanium, it was found that TiN coatings of up to 100 micron thickness could be easily produced. Furthermore, (100) texturing of the TiN could be obtained for certain timings of the FEL, which could be explained by the numerical modeling and solidification behavior during the FEL irradiation.

(1) E. Carpeno, M. Shinn, and P. Schaaf. Synthesis of highly oriented TiNx coatings by free electron laser processing of Ti in nitrogen gas. Applied Physics A 80 (2005) 1707-1710.

(2) P. Schaaf, M. Kahle, and E. Carpeno. Reactive Laser Plasma Coating Formation. Surface and Coatings Technology 200 (2005) 608-611.

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**11:06AM I6.00002 Quality Carbon Nanotube Production in Quantity using FEL Radiation**, MICHAEL SMITH, NASA — This abstract was not received electronically.

**11:42AM I6.00003 Applications of X-ray FELs**, JEROME HASTINGS, Stanford Linear Accelerator Center — This abstract was not received electronically.