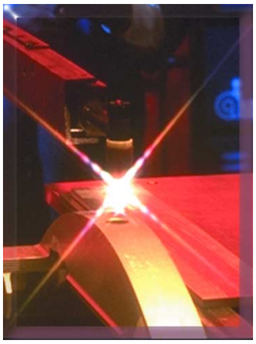
Recent Research

SUMMARIZED BY GEORGE LEOPOLD

These post-deadline papers were prepared for the 2001 OSA Annual Meeting, October 14-18, 2001, Long Beach, California.



Atom Optics with Giant Quantum Reflection From a Solid Surface

Quantum reflection of an atomic wave from a solid surface is caused by the attractive van der Waals force acting on the atom near the surface. The researchers had previously verified the quantum reflection of a cold neon atomic beam from a silicon surface. In this research they demonstrate the first known reflective atom-optical elements that use natural interaction of a solid surface, or attractive van der Waals potential. Reflectivity from the surface was shown to increase drastically by modification of the surface to reduce effective density. A flat silicon surface was etched to form the grating structure that consisted of an array of narrow ridges with a periodicity of 10 μm. Using a metastable neon atomic beam, 10% reflectivity was obtained at the normal incident velocity of 20 mm/sec. The researchers said they have also made a reflective beam splitter and reflective amplitude holograms for atoms using this structure as a reflective surface for atoms.

Fujio Shimizu, Institute for Laser Science, University of Electro-Communications, Tokyo, Japan and Jun-ichi Fujita, NEC Fundamental Laboratories, Ibaragi, Japan.

Absolute Testing of Cylindrical Surfaces with Grazing Incidence Interferometry

Grazing incidence interferometry has been used for macroscopic form measurements as well as for surface inspection and shape control of technical work pieces. Accuracy in measuring surface deviation was in the submicrometer range. The researchers note that absolute testing is widely used for flat and spherical surfaces. They report on an absolute test for cylindrical surfaces designed to eliminate systematic errors in interferometers. The test wave front was provided by means of diffractive optical elements (DOEs). A pair of identical DOEs was used for beam splitting and beam shaping. Phase shifting interferometry was used to evaluate the resulting fringes showing surface deviations. Several measurements with different positions and orientations of a test piece could be performed using the technique to determine and eliminate systematic errors. The researchers also proposed a four-position test for cylindrical work pieces using a grazing incidence.

Roland Schreiner and Johannes Schwider, University of Erlangen, Germany

Operation of a 1-W Single-Mode External-Cavity Laser-Diode Array Near 780 nm

High-powered laser-diode arrays (LDAs) with linewidths of about 2 nm have been used to produce samples of laser-polarized helium and xenon. External cavities have meanwhile been shown to significantly narrow the spectral profile for free-running LDAs. The Michigan researchers demonstrated single-mode operation of an LDA in an external-cavity configuration with an observed linewidth of about 120 MHz resolved with active stabilization and improved vibration isolation. An antireflection coating was found to improve stability and tunability beyond the 5-nm range observed. The external-cavity LDA system was constructed from a Littman-Metcalf configuration operating on a dominant single mode. The LDA facet was coated to reduce the gain of the intrinsic laser.

The investigators concluded that an external-cavity LDA with such a high power and narrow bandwidth light source could be used for a range of applications such as high-resolution spectroscopy and laser cooling and trapping.

Burcin Bayram and Timothy Chupp, University of Michigan, Ann Arbor, Michigan.

Scalable Multispectral Semiconductor-Laser Sensing System Using Orthogonal Code-Division Multiplexing

Sensors based on orthogonal code-division multiplexing (CDM) represent a new technique for achieving wavelength discrimination using a single detector. A mid- to near-infrared diode laser spectroscopic sensor employing orthogonal CDM for wavelength discrimination was developed with detector-noise-limited performance. The researchers said that using mW-laser power, the sensor demonstrated high-sensitivity, short-range, open-air gas leak sensing as well as detection of hydrocarbon oil contamination on water. They said the sensor was capable of distinguishing a thin film of hydrocarbon oil contaminating the surface of water from natural oils by observing non-specular reflection from the surface. They also demonstrated the multiwavelength performance needed for a more advanced sensor. They reported that the simulated contamination of a stirred colloidal liquid with a dye was readily detected with high sensitivity.

Z. Morbi, Y. Wang, D.B. Ho, H. Krishnan, H.Q. Le, and S.S. Pei, University of Houston, Texas.

Nonlinear Microstructured Glass Fibers for Optical Signal Processing

The researchers developed microstructure glass technology based on an advanced fiberglass drawing technique that permitted them to fabricate precise glass products with components down to 0.2 μm with accuracy of 0.5-1%. They used special geometric arrangements of fibers with different compound glasses in a bundle. Their drawing technique produced thin fibers with complex structures within their cross sections.

They also investigated numerically nonlinear fibers with uniform cores and cladding consisting of concentric layers with periodically changed refractive index. In another case, they used a periodically changed Kerrlike non-linearity coefficient. They also showed that step-index fibers with chalcogenide glass nonlinear layers or rods in the cladding could be effectively used for short, high-intensity pulse compression and pulse power limiting.

E.V. Becker, N.B. Skibina and V.I. Beloglazov, Technology Equipment Glass Structure, Saratov, Russia and L.A. Melnikov and E.A. Romanova, Saratov State University, Russia.

Decoherence Effects in Practical Quantum Cryptography Key Distribution Based on Polarization-Entangled Photons

Recent experiments involving quantum cryptography key distribution (QCKD) have focused on polarization photon entanglement, a technique based on its intrinsic quantum nature. However, research has shown limits to this approach associated with statistical noise caused by decoherence effects induced by both photon source generation and the measurement system. The Italian team investigated these effects by inducing perturbation in the ideal polarization entanglement in spontaneous parametric-down conversion (SPDC). This yielded errors in the transmitted bit sequence. Since SPDC-based QCKD schemes rely on the measurement of coincidence to assert bit transmission, the researchers developed a statistical model to calculate the density matrix of accidental coincidences. They say their model predicts the quantum bit-error rate and the sifted key before and after error correction, providing a method to compare different security criteria for proposed QCKD protocols. The result is an objective assessment of performance and the advantages of drawbacks of different systems.

S. Castelletto, I.P. DeGiovanna and M.L. Rastello, Istituto Elettrotecnico Nazionale G. Ferraris, Torino, Italy.

Axial Irradiance throughout the Whole Space behind an Annular Aperture

Irradiance distribution in the very near field behind a circular or annular aperture is of interest in many photonics and fiber-optics applications. The investigators performed detailed calculations of the irradiance distribution throughout the entire space behind an annular aperture. They found that the Rayleigh-Sommerfield diffraction integral yielded a solution for the diffracted wave field in the form of an infinite summation when integrated by parts multiple times. Axial irradiance distribution exhibited an oscillatory behavior they said could be interpreted as an interference effect between two edge-diffracted waves. A variety of subtle effects in both the amplitude of the oscillations and the mean value of the axial irradiance in the very near field were also examined as a function of the obscuration ratio.

James E. Harvey and Andrey Krywonos, University of Central Florida, Orlando, Florida.

Optical Microrheology in Localized Coherence Volumes

Several optical techniques have been developed to probe the rheological properties of complex fluids at the microscopic scale. However, these techniques must face the problem of extracting quantitative local information about complex systems. The researchers report on a novel optical technique for microrheological investigations of viscoelastic systems. Dielectric particles under thermal motion were used to probe the mechanical response of fluids. Rheological properties of fluids were inferred by quantifying the fluctuations of the light scattered by particles, which were directly related to position fluctuations of the probes within the fluid. They found that the coherence length of the light and the transversal area of a fiber core define the measurement volume. In this case, volume was on the order of 1 picoliter, opening up a new field of applications. They also reported that the new methodology was applied to a variety of complex fluids, permitting them to investigate refined structure modifications in fibrin solutions containing fibrin strands.

Gabriel Popescu, John Biggerstaff, Shonak Patel, and Aristide Dogariu, University of Central Florida, Orlando, Florida.