Photonic Transistor Realized with Local Plasmon Amplification

Researchers from the Laboratory for Advanced Optical Technology at the National Institute of Advanced Industrial Science and Technology (AIST), the Advanced Technology Research Laboratory at Sharp Corporation, and the Data Storage Technology Center at TDK Corporation have demonstrated a system that has the potential to realize all-thin-film photonic transistors by using local plasmon amplification. Using a technique called super-resolution near-field structure (super-RENS), which was originally developed for optical near-field recording, surface plasmons can be generated, without a prism, by using a specially designed multilayer with a focused laser beam.

In the April 23 issue of *Applied Physics Letters*, J. Tominaga of AIST and co-workers describe a procedure for fabricating a plasmon transistor as well as the experimental setup used to confirm the device. By focusing both a red (635-nm) and a blue (405-nm) laser beam into one small spot on a high-speed rotating optical disk, a large signal enhancement was observed. They found that a plasmon interaction generated between silver light-scattering center and small marks in the optical disk, recorded with a super-RENS, produced a large signal amplification in the spot (<1 mm). The silver light-scattering center was formed by the local decomposition of a silver oxide layer. A modulated signal of the blue laser was enhanced 60× by controlling the red-laser power from 1.5 mW to 3.5 mW. By tuning the size of the light-scattering center, through control of the laser power responsible for generating the scattering center, the signal released from the plasmon reservoir was controlled. In their system, the light-scattering center plays the role of a gate in the photonic transistor.

The researchers' results indicate that a photonic transistor is possible by using local plasmon scattering. The local plasmon photonic transistor has advantages over photonic devices that use surface plasmons. For example, prisms, which were previously required to attain attenuated total reflection, are replaced by a thin film of silver oxide. This enables the devices to be manufactured thinner and smaller, and at a reduced cost, through a combination of micromachining and thin-film technologies. Tominaga believes that "all-thin-film photonic plasmon circuits are no longer a dream, but rather a technology which may soon be manufactured like conventional electronic devices."

STEFFEN K. KALDOR

Optical Recording Fabricated with Dye-Doped Polymer-Dispersed LC Films

A group of researchers from the National Cheng Kung University and the Fortune Institute of Technology in Taiwan has devised a method of recording optical holograph permanent gratings that are electrically switchable. As reported in the April 1 issue of *Optics Letters*, this technique has a combination of high light sensitivity and short recording time.

The recording medium is a homogeneous mixture of liquid crystals, a prepolymer (called NOA65), and a dye (methyl red). Two laser beams (λ = 532 nm, ~6 ns pulses) from a single *Q*-switched Nd:YAG source write the holographic grating. The polymer is then UV-cured at ~11.5 mW/cm^2.

The dye molecules exert a torque on the liquid crystals where they are photoexcited by the laser. This action causes the alignment of the liquid crystals along their director axis. Liquid crystals remain in random orientation in the "unwritten" regions, as confirmed by both polarization and diffraction experiments. According to the researchers, the ease of sample preparation, the good light sensitivity, and the fast recording time of this technique may lead to many future advancements in holography. Although the diffraction grating was "permanent," diffraction could be turned off by applying an ac rms voltage of 140 V at 1 Hz.

JUNE LAU

Seeding of the Reaction-Bonded Aluminum Oxide Process with Submicron Al_2O_3 Particles Reduces the Transformation Temperature

A team of researchers at The Pennsylvania State University has demonstrated that in the production of ceramics, seeding the reaction-bonded aluminum oxide (RBAO) process with ~0.2-μm-sized α-Al_2O_3 particles decreased the phase-transformation temperature to ~962°C. The fine microstructure of the compacts decreases the sintering temperature and improves the densification.

"Reaction-based processing is a novel approach for the fabrication of ceramics and ceramic-matrix composites," said Gary Messing, professor of materials science and engineering at Penn State. "The process is very attractive, as it is environmentally benign and gives compacts with a high green strength and a low net shrinkage."

In the RBAO process, which was developed in 1989, a mixture of aluminum and α-Al_2O_3 powders is used to produce dense α-Al_2O_3-based composites. After attrition milling, the resulting slurry is dried and pressed into pellets. Upon heating, the Al is oxidized and forms γ-Al_2O_3. Further heating leads to transformation to α-Al_2O_3 above 1100°C and sintering above 1550°C.

"There was some evidence in our earlier work that the γ-Al_2O_3 to α-Al_2O_3 transformation can have a significant effect on sintering kinetics, temperature, and microstructure," said Ender Suvaci, who did his PhD research on RBAO with Messing before accepting a position as an assistant professor at Anadolu University in Turkey. "γ-Al_2O_3 can be seeded with α-Al_2O_3 to decrease the sintering temperature, so we decided to investigate whether the RBAO process could be seeded by using fine α-Al_2O_3 starting particles, too."

As reported in the March issue of the *Journal of the American Ceramic Society*, the team carried out comparative studies on two composites using coarse (~6–10-μm) and fine (~0.2-μm) α-Al_2O_3 starting powders. This resulted in a higher seed frequency than the intrinsic nucleation density (2.9×10^{14} as compared to 1.1×10^{11} seeds/cm^3 γ-Al_2O_3) for the fine powder, while the value for the coarse powder is lower (1.1×10^{10} seeds/cm^3 γ-Al_2O_3). The transformation of the as-formed γ-Al_2O_3 to α-Al_2O_3 started at 963°C and 1052°C for the fine and coarse mixtures, respectively, demonstrating the successful seed effect. Sintering was observed at temperatures as low as 1135°C in the composite using fine α-Al_2O_3 (~127°C lower than in the coarse sample). The smaller particle size resulted in better densification during sintering.

Messing said, "Although shown for RBAO, it is clear that seeding is effective for other reaction-based ceramics and especially mixed metal-oxide ceramics where the phase transformation is nucleation-controlled."

CORA LIND

Real-Time X-Ray Microbeam Technique Used to Study Electromigration in Al(Cu) Conductor Lines

Researchers from the IBM T.J. Watson Research Center in Yorktown Heights, NY, and the Microelectronics Division in East Fishkill, NY, have developed an x-ray microtopography technique for studying stresses and interface integrity in thin-film/semiconductor substrate composites. Using this technique, they have measured the evolution of electromigration-induced stress gradients and Cu concentration in Al(Cu) conductor lines. This *in situ* method, which has a strain sensitivity of 10^{-7}, allows for detection of the stress gradient at both low current densities (10^4–10^5 A/cm^2) and early times.

As reported in the April 30 issue of *Applied Physics Letters*, thin-film Al-0.25%Cu conductor lines (200 μm long × 10 μm wide × 0.5 μm thick) deposited on silicon (100) substrates and passivated

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