Dye-DNA-Lipid Thin Films Exhibit Durable Amplified Spontaneous Emission

A considerable obstacle in the current development of solid-state lasers is durability. Researchers at the Chitose Institute of Science and Technology, Japan, have demonstrated that thin films composed of DNA, lipid, and a hemicyanine dye have the potential for a practical, durable, solid-state laser.

As reported in the August 19 issue of *Applied Physics Letters*, Y. Kawabe and coworkers fabricated thin films by casting on Teflon plates a dichloromethane-methanol solution containing DNA-hexadecyltrimethylammonium (HTMA) and 4-[4-(dimethyamino) stylyl]-1-dococylpyridinium bromide (DMASDPB), a derivatized hemicyanine dye known for its nonlinear optical properties. Self-standing films were formed by evaporating the solvent in vacuum. Film thickness was controlled by varying the concentration. Fluorescence enhancement of DMASDPB in DNA was previously confirmed.

Threshold-energy levels were determined by measuring the light intensity emitted from the samples as a function of pump-pulse energy. The output of a frequency-doubled Nd^{3+}:YAG laser (λ = 532 nm, τ_p = 7 ns), used as the pump source, was focused with a normal incident angle onto a 1 mm × 5 mm stripe on the sample. The emitted light was observed perpendicular to the incident beam along the direction of the stripe.

Emission peaked at 631 nm under low-intensity pumping. A shift in the emission peak to 624 nm with concomitant spectral narrowing were observed under high-intensity pumping. While output energy is proportional to pump energy in the low-intensity region, superlinear dependence is evident for energies greater than 0.5 mJ/cm^2. The researchers attribute the spectral narrowing to amplification because the narrowing and superlinear enhancement occur at the same intensity. Amplification occurs at relatively low self-absorption. In addition, the emitted light is linearly polarized parallel to the film surface, indicating enhanced amplification. The researchers conclude from these results that amplified spontaneous emission occurs in the DMASDPB-HTMA films.

The role played by DNA was investigated in two control experiments. First, thin films were fabricated with poly(methyl methacrylate) and DMASDPB. The resulting films showed strong fluorescence under the same pumping conditions, but neither intensity enhancement nor spectral narrowing was observed. In the second control experiment, a simple laser cavity containing a chloroform solution of DMASDPB was prepared. No indication of lasing was observed. The same apparatus confirmed lasing for some conventional laser dyes as well as for a chloroform solution of DMASDPB and HTMA. The researchers believe that this clearly demonstrates that DMASDPB acquires the ability to lase through its interaction with DNA, which likely alters the dye's electronic state. Further structural and spectroscopic studies to investigate the details of the dye–DNA interaction are planned by the researchers.

In this preliminary study, which was performed in air at room temperature, a reduction in lasing performance of only a few percent was observed after two hours of operation; the total fluence of energy during the test was 210 J/cm^2. The researchers believe that the low threshold, good performance, and long durability exhibited by their DMASDPB-HTMA films demonstrate their potential for practical use as solid-state lasers, especially because their method can be applied to chromophores other than conventional laser dyes.

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DNA-Templated Nanowire Fabrication Technique Developed

As the feature sizes of electronic circuits approach the limits of optical lithography, the costs of traditional micro- and nanolithography techniques used in the electronics industry will become unacceptably high. Recently, several groups have studied approaches using DNA for nanowiring. However, due to the relatively poor intrinsic electric conductivity of DNA, metallization is necessary. In search of new fabrication technologies, a research group from Sony International (Europe) GmbH reported in the September issue of *Nano Letters* on their technique for metallizing DNA using negatively charged tris(hydroxymethyl)phosphine-capped gold nanoparticles (THP-AuNPs).

An aqueous colloidal sol of THP-AuNPs was synthesized by mixing $HAuCl_4$ solution and hydrolyzed tetrakis(hydroxymethyl)phosphonium chloride solution. The resultant particles were characterized by lithium-ion exchange, inductively coupled plasma-atomic emission spectroscopy analysis, and gel electrophoresis. The results showed that the particles were negatively charged with an average individual net charge of approximately 15 *e*.

Two steps are involved in metallization: formation of conjugates between DNA and metal nanoparticles (NPs) and enlargement of the NPs by electroless plating. In the first step, *in situ* or *ex situ*

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