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L A S E R S

An All Plastic Distributed Feedback Laser

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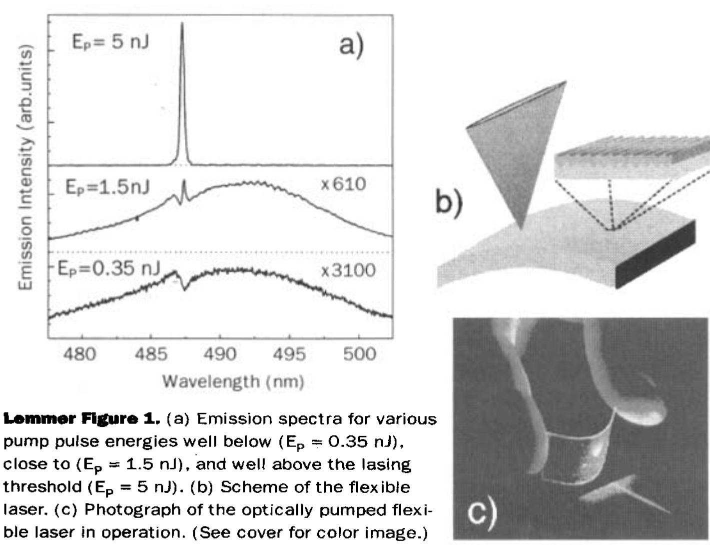
The first devices using organic light-emitting thin-films are now available on the market. Organic light-emitting devices (OLEDs) are expected to play a significant role in future display technologies. In addition to the use of thin organic films in electroluminescence applications, organic injection lasers appear realizable due to the recent discovery of gain narrowing and lasing in conjugated polymers.[1–3] The ultimate goal is the design of an electrically pumped organic laser that maintains the most attractive advantages of organics, *i.e.*, low-cost fabrication of large-area devices and mechanical flexibility.

We have recently fabricated an optically pumped flexible distributed feedback polymer laser.[4] Starting with a flat substrate made of poly(ethylene terephtalate), a periodic height modulation is introduced into an acrylic coating by an embossing process. The substrate, patterned without lithography, is then directly covered with a spin-coated film of a ladder-type poly(p-phenylene) conjugated polymer (LPPP). The conjugated polymer with a refractive index of approximately 1.7 forms the high index part of an asymmetric planar waveguide. Distributed feedback is provided by the diffraction of waveguided light at the corrugated substrate. With a grating period of 300 nm, second-order diffraction supplies the positive feedback necessary for lasing operation. Waveguided photons are coupled out by first-order diffraction into a direction perpendicular to the film leading to vertical laser emission.



Lemmer Figure 1. (a) Emission spectra for various pump pulse energies well below (E_p = 0.35 nJ), close to (E_p = 1.5 nJ), and well above the lasing threshold (E_p = 5 nJ). (b) Scheme of the flexible laser. (c) Photograph of the optically pumped flexible laser in operation. (See cover for color image.)

Optical excitation of our plastic laser with femtosecond laser pulses at 400 nm stimulates vertical single-mode laser radiation at 488 nm. Figure 1a displays the pump intensity dependence of the emission spectra in the spectral range of the first vibronic side band. At a threshold pump pulse energy of 1.5 nJ the spectrum collapses from the broad photoluminescence spectrum to a single-mode laser emission at higher pump pulse energies. The laser light is emitted vertically, exhibiting low divergence perpendicular to the grating (see Fig. 1b and c). The lasing device is remarkably stable, showing almost no degradation for more than 10^7 laser pulses when kept in vacuum. The lasing threshold observed in our experiments corresponds to an excitation density of 2×10^{17} cm^{-3}. It is interesting to note that carrier densities in this range have already been demonstrated in conjugated polymer LEDs driven by short electrical pulses.[5] The organic injection laser is therefore feasible. A key issue, however, is to ensure that the major part of the carrier forms neutral excitations (excitons) that can undergo radiative recombination. Current research focuses on the design of suitable heterostructures to achieve this goal.

Future flexible vertically emitting polymer laser devices might lead to novel applications in measurement instrumentation as well as in memory and display technology that rely on large area emitters and geometries not accessible to conventional inorganic laser materials.

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Diode-pumped Tunable Room-temperature Lasers Based on F_2^+ and F_2^- Color Centers in LiF

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Pulsed room-temperature color center lasers based on F_2^+ and F_2^- centers in crystals are presently reliable sources of tunable radiation with fundamental frequencies in the 820–1340 nm spectral region.[1] Ever since the discovery of Cr^{4+}:forsterite and Ti^{3+}:sapphire lasers, the LiF:F_2^{+*} and LiF:F_2^- color center tunable systems have attracted the attention of researchers. It is still the only type of the material that provides smooth tunability in the 820–1310 nm region (using two active elements and one YAG:Nd^{3+} laser as a pumping source), and high gain of the F_2^+ and F_2^- centers in LiF provides almost no delay between pumping and lasing pulses as well as no de-