surface. Very thin polymer layer was deposited on sidewall because little polymer initiator (Al compound) was produced. As a result, waveguide with no lateral erosion and very smooth sidewall (R_a = 20 nm) was etched.

In conclusion waveguides with vertical profile and smooth sidewall can be fabricated using an etch chamber equipped with a silicon clamp.

1. F. Ladouceur, J.D. Love,T.J. Senden, IEE Proc.-Optoelectron. 141(4) (1994) 242.
2. J.P.R. Lacey and F.P. Payne, IEE Proc. 137(4) (1990) 282.
3. A.J. McLaughlin, J.R. Bonar, M.G. Jubber, P.V.S. Marques, S.E. Hicks, C.D.W. Wilkinson and J.S. Aitchison, CLEO '97., Summaries of Papers Presented at the Conference on, Volume: 11 Page(s): 508–509.
4. E.S. Bulat, M. Tabasky, B. Tweed, C. Herrick, S. Hankin, N.J. Lewis, D. Oblas and T. Fitzgerald, J. Vac. Sci. Technol. A11 (4) (1993) 1268.
5. Alfred J. van Roosmalen, Vacuum 34(3–4) (1984) 429.

CTuM31 1:00 pm

Fast and Slow Photoresponses in CMR Thin Films

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As has been known, colossal magnetoresistance (CMR) materials exhibit a sharp insulator-metal transition at room temperature range, which makes them promising in radiation sensor applications. In our work, the photoresponse to the laser pulsed radiation as a change in the resistance in the thin $La_{0.6}Sr_{0.4}MnO_3$ film was studied as a function of temperature.

Two different light sourses were used. A cw Ti-Sapphire laser at 800 nm modulated with an optical chopper and a frequency doubled q-switched Nd:YAG laser were used to observe the time dependence of the electrical response.

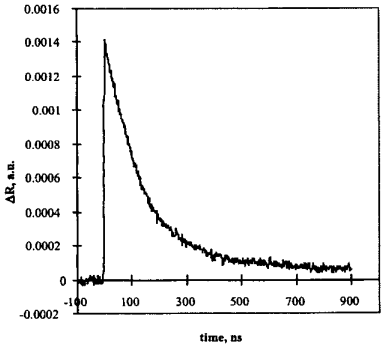
The "slow" photoresponse to cw radiation has opposite signs below and above the transition temperature: a decrease in the resistance at $T > T_c$, and an increase at $T < T_c$. This is a bolometric response determined purely by dR/dT. The time constant (about 1 ms) is determined by thermal conductivity between the film and substrate.[1]

The electric response to the nanosecond laser pulses at 1.06 μm and 0.53 μm represents a sum of two components: a fast one with a very short rise time and a relaxation time of about 100 ns, and an additional slow one (of the bolometric origin) observed as a step function in this time scale (Fig. 1).

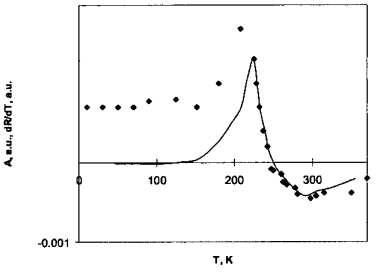
Like the slow response, the fast response is negative at $T > T_c$ and positive at $T < T_c$. However, the dependence A(T) is different from dR/dt in the low temperature range (Fig. 2).

The relaxation time of the fast response depends strongly on temperature. We observed a singularity in the dependence $\tau(T)$ in the T_c vicinity, see Fig. 3.

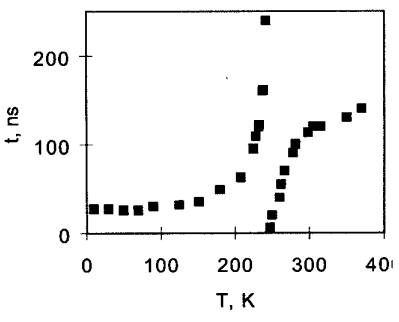
We suggest the following explanation of the fast response behavior. As known, in colossal magnetoresistance materials the maximum of the resistance coincides with the transition from the paramagnetic to the ferromagnetic states. At $T > T_c$, conductivity is determined by small polaron hopping. Heating of the carrier subsystem at these temperatures results in an increase in the hopping probability, and thus, a decrease in the resistance. Below T_c in according to the double exchange model, a probability of the charge transfer between Mn^{4+} and Mn^{3+} ions depends on the mutual orientation of Mn ion spins. Carrier subsystem photoexcitation in the film in ferromagnetic state leads to the appearance of the opposite spin carriers and an increase of the resistance.[2]



CTuM31 Fig. 1. A typical photoresponse in CMR film.



CTuM31 Fig. 2. Fast photoresponse amplitude vs temperature (dots). Solid line is slow photoresponse and dR/dT (both coincide in arbitrary scale).



CTuM31 Fig. 3. The relaxation time of the fast response in the dependence on temperature.

Thus, CMR thin films demonstrate two kinds of the photoresponse to the pulsed laser illumination. The slow response has a bolometric origin. The fast response below T_c is determined by spin flip excitations in the ferromagnetic state.

1. Yu. P. Gousev., A.A. Verevkin, H.K. Olsson, N. Noginova, E.S. Gilman, K.H. Dahmen, "Photoresponse of Thin $La_{0.75}Ca_{0.25}MnO_3$ Films to Laser Radiation", Journal of Low Temp. Phys. 117, 1665–1668 (1999).
2. A.P. Ramirez, "Colossal magnetoresistance", J. Phys.: Condens. Matter 9, 8171–8200 (1997).

CTuM32 1:00 pm

Strong enhancement of spontaneous emission in hydrogenated amorphous silicon nitride coupled-microcavity structures

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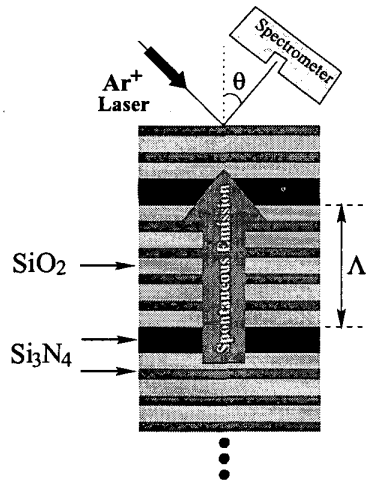
Recently, we have reported a new type of propagation mechanism in which photons move along the localized coupled-cavity modes.[1] Moreover, it was observed that the group velocity tends towards to zero and photon lifetime increases drastically at the coupled-cavity band edges.[1] In this work, we experimentally demonstrate the modification of spontaneous emission from the hydrogenated amorphous silicon nitride layers in a coupled-microcavity (CMC) structure.[2]

Ability to control spontaneous emission is expected to have a practical importance in certain commercial applications. Thus, in the past decade, photonic band gap materials were proposed for alteration (inhibition and enhancement) of the spontaneous emission.[3–5] Since the density of electromagnetic modes $\rho(\omega)$ is modified by the surrounding environments, the spontaneous emission from atoms can be controlled by placing the atoms inside cavities. The spontaneous emission rate is directly proportional to the photon density of modes via Fermi's Golden rule: $\Gamma_s \propto \rho(\omega) \propto 1/v_g$. Thus, it is expected that spontaneous emission from a CMC structure can be enhanced due to small group velocity.

The CMC structure was composed of alternating silicon-oxide (SiO_2) and silicon-nitride (Si_3N_4) multilayers. The cavities were introduced by doubling the deposition time of the silicon-nitride layer with an intercavity distance Λ = 4.5 pairs. The SiO_2 and Si_3N_4 layers were deposited on glass substrates by plasma enhanced chemical vapour deposition (PECVD) at 250°C. Nitrogen (N_2) balanced 2% silane (SiH_4), pure ammonia (NH_3) and nitrous oxide (N_2O) were used as the silicon, nitride and oxide sources, respectively. The refractive indices and thicknesses of layers were $n_{SiO}2$) = 1.46, $n_{Si}3N_4$ = 1.98, $d_{SiO}2$ = 124.8 nm, and $d_{Si\$;3}N_4$ = 92.0 nm. The structure of the sample and experimental setup are shown in Fig. 1.

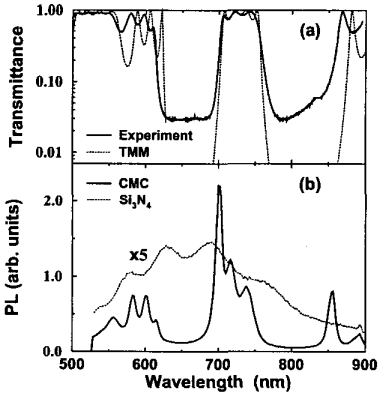
The room temperature photoluminescence (PL) measurements were performed using a 1-m double monochromator, equipped with a cooled GaAs photomultiplier tube and standard photon counting electronics, at $\theta = 0°$ with respect to the surface normal and with a spectral resolution



CTuM32 Fig. 1. Schematics of a coupled-microcavity structure and our experimental setup for measuring the photoluminescence spectra.

2nm. An Ar^+ laser operating at 488 nm with 120 mW output power was focused with a 15-cm focal-length cylindrical lens on the sample. The tranmission spectrum was taken by an Ocean Optics S2000 fiber spectrometer.

Figure 2(a) shows the measured (solid line) and calculated (dotted line), by using transfer matrix method (TMM), transmission characteristics of the CMC sample with four cavities. Nearly 100 percent transmission was achieved throughout the CMC band. The PL spectra of a single Si_3N_4 layer (dotted line) and the CMC sample (solid line) were displayed in Fig. 2(b). The PL spectrum of Si_3N_4 layer was multiplied by a factor of five. We observed that (1) spontaneous emission was enhanced at the photonic band edge and (2) a strong enhancement of spontaneous emission was achieved for a wide range of wavelengths (cavity band) extending from 690 to 770 nm. It is important to note that the spontaneous emission displayed an oscillatory behavior near the edge of photonic band gap.[2]



CTuM32 Fig. 2. (a) Measured (solid line) and calculated (dotted line) transmission through the SiO_2/Si_3N_4 coupled-microcavity (CMC) structure. (b) Measured photoluminescence from the hydrogenated amorphous silicon thin film (dotted line) and the coupled-microcavity structure (solid line).

In summary, we have investigated photoluminescence from a hydrogenated amorphous silicon nitride CMC structure. It was observed that a strong enhancement of spontaneous emission can be achieved throughout the cavity band. These results open a variety of possibilities in optoelectronic applications such as coupled-cavity broadband high brightness light emitting devices (CCLED).

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References

1. M. Bayindir, B. Temelkuran, and E. Ozbay, Phys. Rev. Lett. **84,** 2140 (2000); M. Bayindir, S. Tanriseven, and E. Ozbay, Appl. Phys. A **71,** xxxx (2000); M. Bayindir and E. Ozbay, Phys. Rev. B **62,** R2247 (2000).
2. M. Bayindir, S. Tanriseven, A. Aydinli, and E. Ozbay, Submitted to Appl. Phys. Lett. (November, 2000).
3. E. Yablonovitch, Phys. Rev. Lett. **58,** 2059 (1987).
4. S. John and T. Quang, Phys. Rev. A **50,** 1764 (1994).
5. M. D. Tocci, M. Scalora, M.J. Bloemer, J.P. Dowling, and C.M. Bowden, Phys. Rev. A **53,** 2799 (1996).
6. A. Serpenguzel, A. Aydinli, A. Bek, and M. Gure, J. Opt. Soc. Am. B **15,** 2706 (1998); F. Giorgis, Appl. Phys. Lett. **77,** 522 (2000).

CTuM33 1:00 pm

Large scale microdischarge arrays: fabrication and characterization

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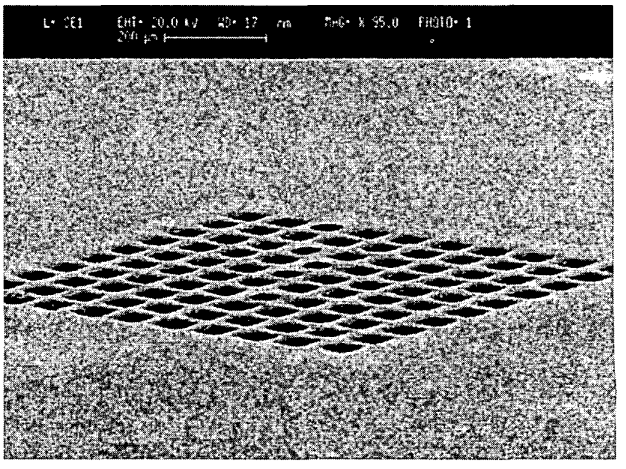
Microdischarges exhibit several novel characteristics and, specifically, with respect to power loading and operational pressures. The feasibility of fabricating microdischarge device in Si was first reported in 1997 and the operation of small (5) arrays of devices having planar cathodes was demonstrated in 1998.[1,2] Intense emission was observed from these arrays but exploiting the capability and versatility of semiconductor microfabrication techniques to produce sub-100 μm devices is essential if the potential of microdischarge devices is to be realized.

Microdischarge devices and arrays having inverted square pyramidal cathodes are described in this paper. The integration of these new photonic devices into Si is attractive for several applications, including displays, chemical sensors and frequency standards. The devices fabricated to date have square pyramidal cathodes, $(50\ \mu m)^2$ of the base (Si wafer surface) and 35 μm in depth., produced by wet etching.[3,4] The dielectric for the device consists of a ~8 μm thick polymer film as well as a 1.15 μm Si_3N_4/SiO_2 layer. A 1500 Å Ni film serves as the anode. Two types of device arrays ranging from 2×2 to 10×10, have been fabricated. Our first tests involved arrays in which the devices have a common anode but more recent tests have been conducted with groups of 3×3 arrays on the same Si wafer but having separate power feeds. Fig. 1 is a photograph of a 10×10 array of devices having a common power feed. A portion of a device having eight 3×3 array, arranged in a circular pattern, is shown in Fig. 2.

The results show that the combination polymer/Si_3N_4/SiO_2 dielectric extends the device lifetime dramatically as compared to employing only the polymer film as the dielectric. Furthermore, one screen electrode increases the maximum output power produced by neon discharges by more than an order of magnitude relative to that for a Ni film anode. To date, stable, intense discharges have been produced in $(50\ \mu m)^2$ devices at Ne pressures up to 1200 Torr. Single device operating voltages as low as 90 V have been obtained and typical operating parameters for a 10×10 array, for example, are ~240 V, 20 mA. All of the arrays have V-I characteristics exhibiting positive differential resistance. Details concerning the electrical and optical characteristics of these devices, as well as their applications, will be discussed.



CTuM33 Fig. 1. SEM image of 10×10, $(50\ \mu m)^2$ array with common power feed.