QThD5

Novel Optical Bistability and Hysteresis in Multiple-Quantum-Well Lasers

Gary Chen, Ching-Fuh Lin, Miin-Jang Chen, and Bor-Lin Lee
Department of Electrical Engineering

and
Graduate Institute of Electro-Optical Engineering
National Taiwan University

Taipei 106, Taiwan ROC
Tel 886-2-23635251 ext. 339/Fax: 886-2-23638247

Bistable semiconductor lasers have potential applications in future optical communication, optical switching, optical computing, and so on [1]. Although gain saturation alone could account for the bistability, the inclusion of absorption saturation could make the bistability easier to occur [2]. As a result, multi-electrode semiconductor lasers are usually used for optical bistability. In this work, we report that bistability exists in the semiconductor lasers without multiple sections. Using multiple quantum wells of different widths, both gain quenching and saturable absorption could occur in the same region for bistability. The semiconductor lasers that exhibit optical bistability have four quantum wells with their widths 20 Å, 33 Å, 56 Å, and 125 Å, respectively, separated by 150 Å $\text{Al}_{0.2}\text{Ga}_{0.8}\text{As}$ barrier. An external-cavity configuration with broadband tunability was used for the bistability experiment. Different behaviors of bistability had been discovered for different wavelengths. Fig 1 shows an L-I curve with obvious bistability. The details of experiments will be discussed in the presentation.

Fig 1 An L-I curve at lasing wavelength of 816 nm that exhibits hysteresis.

- References: [1] Hitoshi Kawaguchi, IEEE J. Select. Topics Quantum Electron. 3, 1254-1270 (1997).
[2] Ching-Fuh Lin and Pei-Cheng Ku, IEEE J. Quantum Electron. 32, 1377-1382 (1996)

QThD6

OPTICAL BI- AND TRI-STABILITY BY EXCITATION OF SURFACE ELECTROMAGNETIC WAVES AT BOUNDARIES OF ONE- AND TWO-PHOTON RESONANT MEDIA

L. M. Kocharyan

Department of Physics, Yerevan State University, A. Manoogyan str.1, Yerevan 375025, Armenia,

Phone: (3742) 556383, Fax: (3742) 151087

The resonant nature of the excitation of surface electromagnetic waves (SEWs), i.e. the resonant dependence of the reflectivity on the incident radiation wavevector component parallel to the interface (surface), k , leads to the nonlinear phenomena arising and particularly optical bi- and multi-stability appearance at relatively small nonlinearities. At such nonlinearities the field-induced variation of SEW wavevector, K , becomes comparable with the width, $\text{Im}(K)$, of the mentioned geometrical (angular) resonance. In this paper the theory of optical bi- and multi-stability at the excitation of TM-polarized SEWs via Kretschmann attenuated total reflection (ATR) scheme (glass prism-metal film-dielectric) in which the dielectric exhibits a relatively small one- or two-photon resonant nonlinearity is presented. The system of equations describing the excitation of nonlinear SEWs is presented in general form for arbitrary type of nonlinearity by means of SEW wavevector nonlinear term, K^{NL} . It is the same form which in case of cubic nonlinearity has been presented in [1]. The value of K^{NL} is determined via [2]:

$$K^{NL} \sim K_0 \int_0^z [P^{NL}(z) + iK_0 K_0^{-1} P^{NL}(z)] \exp(-K_0 z) dz,$$

where x is the SEW propagation direction, z is the direction of perpendicular to metal-dielectric interface, P^{NL} is the amplitude of medium nonlinear polarization, K_0 is the linear term of SEW wavevector, $K_0 = (K_0^2 - (\omega/c)^2 \epsilon_s)^{1/2}$, ϵ_s is the dielectric permittivity of nonlinear medium. In the case of one-photon resonance on the dependence of reflectivity on incident radiation intensity the hysteresis loop of optical bistability arises when the concentration of resonant particles exceeds the corresponding threshold. That threshold is the function of frequency and wavevector mismatches ($\omega - \omega_{21}$ and $k - \text{Re}(K_0)$ respectively, where ω_{21} is the frequency of resonant transition). Optical multistability doesn't arise in the case of one-photon resonance. In the case of two-photon resonance both bistability and tristability may appear on the dependence of reflectivity on incident radiation intensity. The corresponding concentration thresholds are functions of mentioned mismatches. The condition of maximal exhibition of optical tristability has been established analytically in the present paper. When the field enhancement (the square of the field at the interface compared with that in the incident radiation for the linear case) has the value of the order of 10^2 , then for bistability appearance in the case of one-photon resonance and bi- or tri-stability arising in the case of two-photon resonance the incident radiation field must achieve magnitudes of the order of saturation fields for one- and two-photon resonances respectively.

[1] L. M. Kocharyan, Solid State Commun. 74, 193 (1990).

[2] L. M. Kocharyan, "Dispersion relation for TM-polarized surface electromagnetic waves guided by boundary of medium with arbitrary type of small nonlinearity", to be published.