the application of mostly homogeneous electric fields along the coupling axis of the QDMs, gold electrodes are lithographically processed on the sample top.

We investigate the presence and structure of the excited states confined in the system by performing micro-photoluminescence excitation (μ-PLE) spectroscopy using a wide-band tunable Ti:sapphire laser source. For gaining coherent control over the material system by quasi-resonant excitation via higher energetic states and for usage as quantum gates, detailed knowledge about these states is of particular interest. We find numerous excited states in the μ-PLE and analyze in detail their dependence on an applied external electric field along the coupling axis. We find only a very low quantum-confined Stark effect for all the excited states, on the order of the measurement's uncertainty. We also find that the excited states are very similar for different molecules. This indicates on the presence of a mechanism that has a leveling effect for all QDMs. In order to further understand the numerous resonances found by μ-PLE, we perform experiments under quasi-resonant excitation and analyze the emission from the QDM's ground and charged state's depending on lateral electric fields along the molecule's coupling axis and also depending on the excitation power. From these measurements, we can assign the excited states to be located in a potential basin below the QDM which originates from the growth process and levels the differences among the various QDMs. We also find indications on the presence of indirect excitonic states in the ground state, which might lead to the opportunity to build a single photon source, that is delayable via external electric fields.

38.17 Tue 16:00 Poster area, 310

Optical properties of GaAsSb capped InAs/GaAs self-assembled quantum dots under thermal annealing — •José M. Llorens[1], José M. Ulloa[2], and Benito Alén[1] — [1]IMM-Institutode Microelectrónica de Madrid (CNM-CSIC), Isaac Newton 8, PTM, E-28760 Tres Cantos, Madrid, Spain — [2]Institute for Systemsbased on Optoelectronics and Microtechnology (ISOM), Universidad Politecnica de Madrid, Ciudad Universitaria s/n, 28040 Madrid, Spain

InAs/GaAs self-assembled quantum dots (SAQDs) capped by a homogeneous layer of GaAsSb exhibit a strong emission at telecommunications wavelengths even at room temperature.[1] Such feature makes them excellent candidates for acting as gain material in low-threshold solid-state lasers. In addition, the particular band alignment of antimonides with respect to arsenides offers the possibility to induce a type-II valence band layout. Hence, the electron-hole wave function spatial overlap gets dramatically reduced. The increase of the exciton radiative lifetime can be exploited in photovoltaic and memory applications. In this work, we focus on the impact of a rapid thermal annealing (RTA) on the optical properties of two different samples. They consist of a single layer of InAs/GaAs SAQDs covered by a 4.0 nm layer of $GaAs_{1-x}Sb_x$, where the Sb concentration takes the values 12% and 28%.[2] A high temperature RTA induces in the sample with 28% Sb a blue shift of the emission peak, an increase of the integrated intensity and a strong reduction of the inhomogeneous broadening while preserving the long decay times (> 10 ns) typical of type-II band alignment. Indeed, the full width at half maximum (FWHM) and integrated intensity of this type-II sample is comparable or better than that of the type-I counterparts in the same wavelength region. The same RTA treatment in the sample with 12% Sb induces a transition from type-I to type-II together with a blue shift and a narrowing of the emission. Nevertheless, the PL integrated intensity decreases in this case. Complementing this experimental work, we have performed theoretical calculations based on the **k·p** method, where realistic distribution of the strain and piezoelectric potentials have been taken into account. The theoretical calculations have confirmed that a change in the SAQD height and a slight modification of the Sb content in the capping layer can explain the blue shift and the presence or absence of type-I to type-II transition depending of the amount of Sb in the capping layer.

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38.18 Tue 16:00 Poster area, 311

RCWA analysis of periodic and random 3D nanostructures with oxide overlayer — Jun Seok Byun, Tae Jung Kim, Mangesh Diware, Han Gyeol Park, Jun Ho Choi, and •Young Dong Kim — Nano-Optical Property Laboratory and Department of Physics, Kyung Hee University, Seoul 130-701, KOREA

Recently in the semiconductor industry, a great attention has been given to determining the structure of the critical dimension (CD). As the feature sizes approach 40 nm, the semiconductor industry is facing increasingly difficult challenges and one of them is effective metrology. Optical metrology is attractive in manufacturing field for many reasons, such as its nondestructive and noninvasive characteristics, low cost, small footprint, high accuracy, and robustness. Among optical metrology, spectroscopic ellipsometry (SE) has come to be an important method to determine precisely the geometric parameters of patterned structures. From optical data this analysis has been typically done by rigorous coupled-wave analysis (RCWA), where the sample is modeled as a series of layers whose dimensional parameters are determined by fitting the data. The layers are typically approximated as the core material and ambient. However, existence of oxide overlayer or surface roughness layer on the nanostructure came into question to this approximation.

In this work, we present extended RCWA method that accommodates more general structures. To confirm our method we prepared a sample of 3D periodic structures. A Si wafer was patterned using standard photolithography and wet etching process. Optical data were obtained from 190 to 1100 nm wavelength by using SE. In general, natural oxide SiO_2 layer covers Si nanostructure, and its wet etched surface retains surface roughness layer. This roughness was neglected in previous optical analysis. However, it comes to be an important issue in recent process for small line width device. We used Bruggeman effective medium approximation (EMA) with RCWA method for this roughness analysis. We could determine the thickness of the oxide and roughness overlayer with correct shape of Si nanostructure by our extended RCWA method.

We also examine the possibility that RCWA will be useful for determining properties of randomly distributed QD nanostructures, investigating oxide-covered InAs QDs on a GaAs substrate. Ellipsometric parameters of the sample were measured at room temperature from 245 to 893 nm by using SE, investigating the size, interval, distribution density, shape, and its composition. The QD's were considered periodic distribution and covered with oxide overlayer. Our model calculation was in reasonably agreement with the measurements. This implies that the SE with RCWA method is a useful tool for random structure also.

38.19 Tue 16:00 Poster area, 312

Symmetry reduction in multiband Hamiltonians for semiconductor quantum dots: The role of interfaces and higher energy bands — •Stanko Tomic[1] and Nenad Vukmirovic[2] — [1]Joule Physics Laboratory, University of Salford, Manchester, UK — [2]Institute of Physics, University of Belgrade, Serbia

In contrast to a popular belief, spread by interpretation of Ref. [1,2], that multiband envelope function k.p Hamiltonians cannot capture the right symmetry of zincblend QDs, we showed here the opposite [3]. The symmetry group of 8-band k.p Hamiltonian applied to a pyramidal square-based QD is the C4v group. We showed that the inclusion of interface band mixing effects leads to the reduction of symmetry from an artificial C4v, to the correct C2v one. Our analytical derivations, demonstrate that interface effects [4] lead to the reduction of symmetry from C4v to C2v since commutation [D(Rϕ),H(if)]=0, only if ϕ = n.π, where D is the group representation generators. The main manifestation of interface effects are the energy level splitting between (e1, e2), (h0, h1), and (h4, h5) states of the order of 1*3 meV in InAs/GaAs material system. The splitting decrease as the dot size and consequently the volume to surface ratio increase. The inclusion of the additional bands beyond the standard 8 bands also leads to symmetry reduction to C2v, with splitting which are however weaker than the ones due to interfaces. We have found analytically that the 14 band k.p Hamiltonian commutes with the operators of the C2v group representation, i.e. [D(Rϕ),H(14 k.p)]=0 only for ϕ=n.π. We have found indeed that the 14-band k.p Hamitonian is the lowest order multiband Hamiltonian whose kinetic part has the correct C2v atomistic symmetry. This symmetry reduction originates from the coupling between the top of the valence (Γ5v) and the second conduction (Γ5c) band. The observed splittings are comparable to the ones that originate from spin-orbit coupling (these do not reduce the symmetry) and are much smaller than the ones from piezoelectric effect in strained systems. From the many body Hamiltonian constructed from configuration interactions (CI) using single electron orbitals with correct C2v symmetry, we have quantified that the fine structure splitting (FSS) between two bright exitotons in the triplet is 6.4 micro eV due to interface effects and 4.7 micro eV due to explicate inclusion of the second conduction band of the underlying constituent materials (InAs and GaAa). Our work provides a very important conceptual message - with appropriate treatment of relevant effects, the multiband envelope function Hamiltonians are fully capable of capturing the right atomistic symmetry of QD structures.

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38.20 Tue 16:00 Poster area, 313

Enhanced light extraction from SiGe-based photonic crystals — •Reyhaneh Jannesari[1], Magdalena Schatzl[1], Florian Hackl[1], Moritz Brehm[1], Martin Glaser[1], Thomas Fromherz[1], Kurt Hingerl[2], and Friedrich Schäffler[1] — [1]Institut für Halbleiter- und Festkörperphysik, Johannes Kepler Universität Linz, Austria — [2]Zentrum für Oberflächen- und Nanoanalytik, Johannes Kepler Universität Linz, Austria

An optical micro-resonator traps light, thus enhancing the spontaneous emission rate. During the last decades photonic crystals (PhC) have become one of the most promising optical devices for this application. Because of the low losses in glass fibers, the interesting spectral range for telecommunication applications is 1.3-1.5μm. For various applications, it is often critical to design PhC in this spectral range, and, of course, the active material has to emit light in the same range. Aiming toward full compatibility with Si technologies, here we employed self-assembled Ge dots as the active optical material. In order to design the two-dimensional PhC, plain wave expansion (PWE), and finite difference time domain (FDTD) methods were used to optimize the geometry of the PhC, and to determine the radiating modes and their far field. Both, designs for randomly nucleated Ge dots, and for ordered ones in registry with the PhC lattice were simulated and optimized in this way. The two-dimensional photonic crystals were fabricated in a layer stack on silicon-on-insulator (SOI) substrates. The active layers were grown by molecular beam epitaxy (MBE) and consist of