Spatially resolved luminescence properties of quantum well etched microstructures

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Etching of the active material is a ubiquitous processing step for the fabrication of photonic devices such as waveguides, lasers, modulators … Different techniques are available for this step: "wet" etching based on chemical solvents of the semiconductor material, plasma etching (also called reactive ion etching - RIE) or other variants of dry etching techniques such as ion beam etching, … This processing step, at the same time as it allows removing the material to form the desired features, can also affect the properties of this material, in particular in the vicinity of the etched surfaces. We have investigated these effects using spatially-resolved luminescence techniques (photoluminescence-PL, cathodoluminescence-CL). The samples are grown on GaAs or InP substrates. In the presentation, we will focus in particular on quantum well (QW) structures grown on InP, using $InAs_xP_{1-x}$ for the QW material. These QW structures yield PL or CL emission between 1.1 and 1.3 µm, with very sharp lines (full width at half maximum around 4 meV) at low temperature. By measuring PL or CL linescans, or even 2D maps, over the areas close to the etched surfaces, we were able to demonstrate the presence of mechanical stress in these areas [1,2]. The mechanical stress was quantified from the spectral shift of the PL or CL lines, or from the degree of polarization of the PL or CL emission. From the variations in the integrated intensities of the different QW emissions, incorporation of non-radiative defects resulting from dry etching processes (RIE) was demonstrated and quantified [3]. These defects result from the incorporation of ions generated in the plasma (gas) phase, which are accelerated due to the difference between the plasma potential and the sample potential. This acceleration voltage can reach 100 eV or even more for some RIE processes. Such incorporation of ions from the plasma phase was demonstrated to be enhanced by the channeling mechanism [4]. Comparing different etching mechanisms, we could also establish that the presence of these ions in areas close to vertical etched walls of ridge structures induces some stray electric fields which strongly affects the QW luminescence lines [5]. These electric field generate a reduction of the luminescence efficiency through the well-known quantum confined Stark effect [6] and through direct exciton dissociation [7].
All these modifications of the optical properties of QW etched structures are important to consider in the context of the development of photonic devices.

References

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