Gas sensors based on room temperature optical properties of surface QDs

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Self-organized InGaAs QDs are intensively studied for optoelectronic applications. Several approaches are in study to reach the emission wavelengths needed for these applications. The use of antimony (Sb) in either the capping layer or into the dots is one example. However, these studies are normally focused on buried QD (BQD) where there are still different controversial theories concerning the role of Sb. Ones suggest that Sb incorporates into the dot [1], while others support the hypothesis that the Sb occupies positions surrounding the dot [2] thus helping to keep their shape during the capping growth.

In this work we focus on the properties of QDs grown on the epitaxial layer surface. The absence of capping, makes these surface QDs (SQD) to show different confinement properties, which are especially affected by the surface effects. For example, Liang et al proposed the surface states arising from the dangling bonds as the main responsible for the differences in the emitting properties of BQD and SQD [4]. Besides, it has been shown that SQDs emit at longer wavelength due to the strain relaxation [5], since the lack of a capping gives rise to a reduction of the stress in the dot. In addition, SQDs optical properties also depend on the coupling between surface and confined states [3, 5]. All these factors lead to a high surface sensitivity of these SQDs, making them very attractive for the development of biological, chemical and gas sensors.

We have studied the room temperature (RT) photoluminescence intensity changes and its reversibility exposing InGaAs and InGaAsSb SQD layers to different gases. In both cases the RT-PL signal quenches under vacuum conditions. Nevertheless, when PL is measured at atmospheric pressure, the intensity of this signal and its behavior clearly depends on the gas employed to fill the cavity. For example, in fig. 1 we show the evolution of the PL signal in both samples when they are exposed to air, then to a pure O_2 atmosphere and afterwards exposed back to air. We have obtained a strong decrease under oxygen (compared to air) for both samples. However, the process is irreversible for the InGaAs SQDs sample and reversible for the InGaAsSb SQDs sample.

These results obtained suggest that the Sb protects the QD from the oxidation. In this work we will show the PL behavior of several SQD samples grown by MBE under different environmental conditions, studying the importance of Sb and demonstrating the great potential of InGaAsSb SQDs for gas sensing applications.

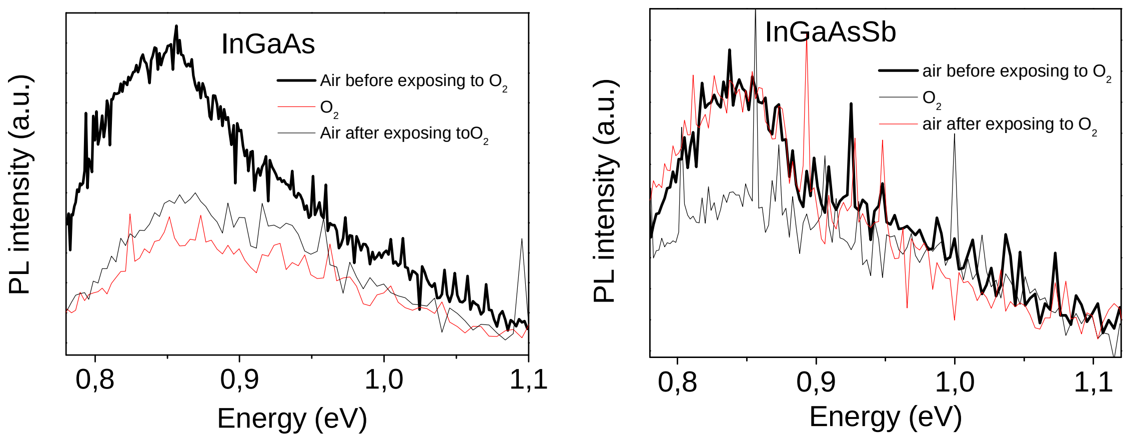

Figure 1. Evolution of the PL intensity of InGaAs and InGaAsSb SQDs under different atmospheres: air, O2 and air again.

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