Exciton-Polariton Lasing Enabled by Etching and Surface Processing of Horizontal GaAs/AlGaAs Waveguide

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Exciton-Polaritons are elementary excitations arising from the strong coupling between a photonic cavity mode and an excitonic resonance. To date, these particles have been widely studied[1] in vertical microcavities composed of an active material. Embedding the device between two highly reflective mirrors, usually made of GaAs and AlGaAs layers, leads to new properties because of the hybrid light-matter inner structure. However, microcavities do not guarantee a facile manipulation of the photonic mode. In fact, a deep etching process is required to get access to the active material where light is confined.

An alternative interesting platform is constituted by horizontal waveguides[2], whose core can be easily patterned with a shallow etching to introduce new functionalities. Here we present the fabrication and characterization of patterned waveguides composed of GaAs quantum wells and AlGaAs barriers. The patterning consists of linear gratings 90nm deep where the control over periodicity and the grating filling factor were found to be of the utmost importance to introduce new properties in our polariton system.
This peculiar grating involves new terms in the system Hamiltonian used to couple propagating and counter-propagating polariton modes. The proper engineering of such pattern ensures the achievement of coherent emission of light relying on the hybrid nature of polaritons in a horizontal slab configuration. In this framework, we will present how the etched grating of Figure 1 can be fabricated via e-beam lithography and ICP-Chlorine, and how the sample quality can be furtherly improved by atomic layer deposition post-processing.

In turn, we assess the impact of the designed pattern over the polariton lasing threshold and the characteristics of its emission. Moreover, we achieve coherent emission from an exciton-polariton Bose-Einstein condensate. Emission from such long lifetime states, combined with the light-matter nature of exciton-polaritons paves the way towards threshold-less coherent light sources.

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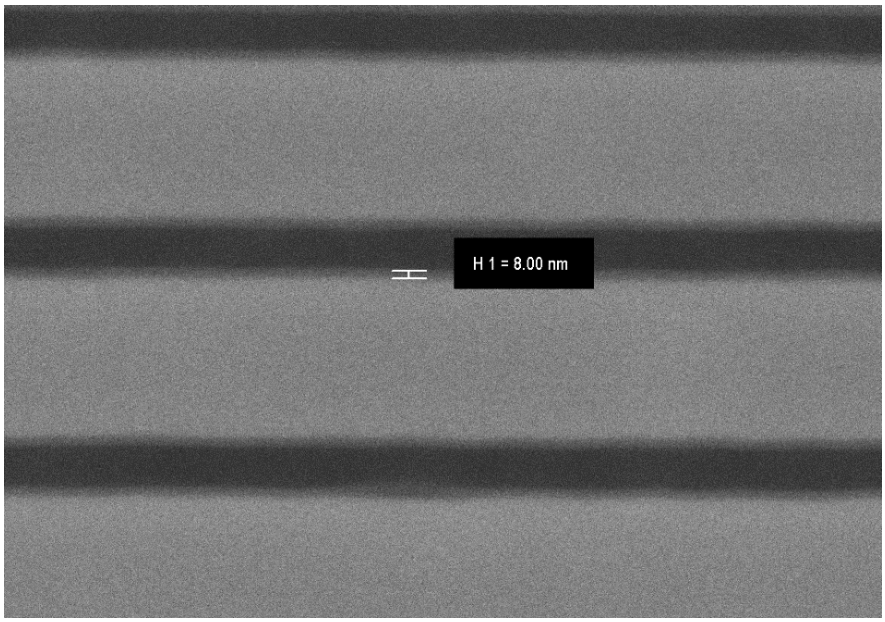

Figure 1: The SEM Image shows a 90nm deep grating etched in a GaAs/AlGaAs heterostructure with a passivation composed of 8nm of Al_2O_3.