Abstract

Semiconductor nanostructures, known as *quantum dots*, have been extensively investigated in the last two decades due to their interesting electronic and optical properties. The importance of these systems comes from not only their exciting physics, but also the potential applications in interdisciplinary fields like quantum information processing and solid-state lasers. Incorporation of quantum dots in optical cavities enhances light-matter interaction, and therefore allows for cavity quantum electrodynamics experiments in solid-state systems. It will also possibly lead to new applications as thresholdless lasers and quantum information devices.

So far, many types of cavities have been introduced. Among them, 2D photonic crystal cavities are considered to be the most promising systems. They support high quality factor and very small mode volume, i.e., comparable with the wavelength of light $(\lambda/n)^3$. Moreover, owing to their planar nature, they are easy to fabricate and compatible for monolithic on-chip integration.

This thesis discusses the design, fabrication, and characterization of photonic crystal cavities with embedded InGaAs quantum dots. Cavities with different geometries are investigated, including H1, H2, L3 and L5. The main focus is on H2 type, consisting of a defect formed by omitting seven air holes in the center of a triangular lattice. The design and simulation of the cavities are performed by using the Finite-Difference Time-Domain method. It is found that by engineering the air holes surrounding the cavity, the quality factor can be increased significantly by the gentle mode confinement method.

The quantum dot samples are grown by using molecular beam epitaxy technique. Then, the photonic crystals are produced by using electron beam lithography and etching techniques. The fabrication process is developed and optimized in order to obtain high quality GaAs photonic crystal membranes.

The cavities are characterized by using photoluminescence technique at low temperature. Polarization-dependent measurements are also performed in order to identify the cavity modes. The results are in good agreement with our theoretical calculations. Finally, the p-shell Rabi oscillations of a single quantum dot in a modified H2 photonic crystal cavity are investigated.