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13. ABSTRACT (Maximum 200 words)

High resolution lithography and directional ion etching are increasingly important for the fabrication of nanostructures. As part of this equipment proposal, a reactive ion etching system was purchased from Oxford Instruments for $305,000. The Army Research Office provided $274,000, and Caltech cost share amounted to $31,500. This instrument was connected and etching conditions were optimized for the fabrication of nanostructures in silicon, silicon dioxide and gallium arsenide. In this final progress report, we will present some examples of functional devices which have been defined by using this very capable ion etching system.

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SUBMITTED FOR PUBLICATION TO (applicable only if report is manuscript):

Sincerely,

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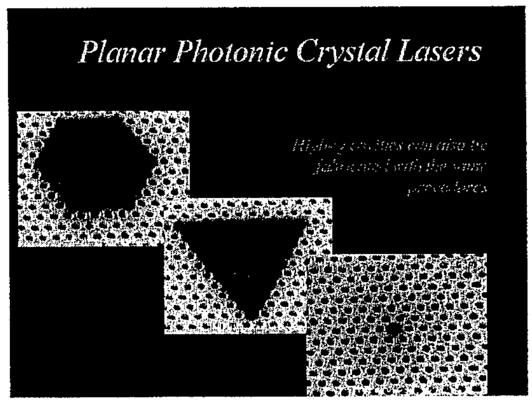
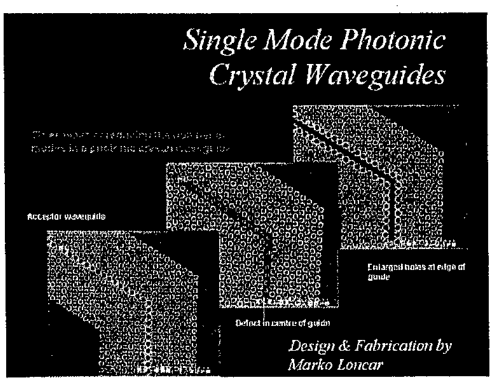
Aim: Inductively Coupled Plasma Reactive Ion Etching system

High resolution lithography and directional ion etching are increasingly important for the fabrication of nanostructures. As part of this equipment proposal, a reactive ion etching system was purchased from Oxford Instruments for $305,000. The Army Research Office provided $274,000, and Caltech cost share amounted to $31,500. This instrument was connected and etching conditions were optimized for the fabrication of nanostructures in silicon, silicon dioxide and gallium arsenide. In this final progress report, we will present some examples of functional devices which have been defined by using this very capable ion etching system.



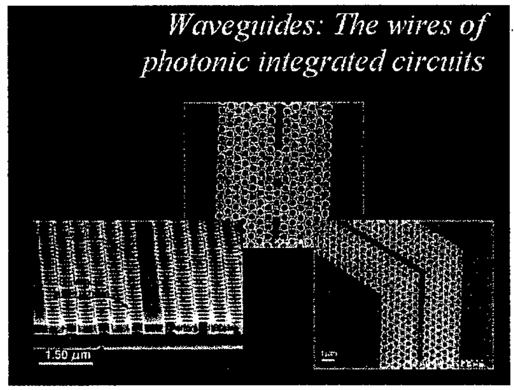
Photonic Crystal Nanocavities

By using the ICP-RIE system, we have fabricated optical nanocavities in both GaAs and Si with high fidelity and resolution. High Q resonances were measured in these cavities, with Q values of up to 2800 for cavities as small as 0.03 cubic microns (or $0.1(\lambda/2)^3$). Such cavities will be very useful for filtering light and as modulators, lasers, and optical switches in nanophotonic integrated systems. Figure 1 shows a typical nanocavity which has been defined in a thin slab of InGaAsP, whereas Figure 2 shows a nanocavity fabricated in InGaAs/GaAs quantum dot material. The sidewall quality of these structures strongly influences the quality of the optical resonator, and the new ICP-RIE system provides us with excellent sidewalls with very little surface roughness.

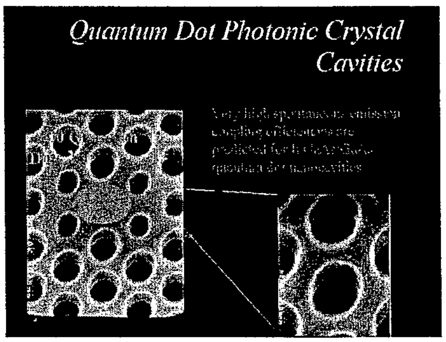


Photonic Crystal Waveguides

Optical waveguides are necessary for the routing of light within small geometries. Such waveguides typically suffer from scattering losses if sharp bends are included. To avoid these scattering losses, and still obtain high quality bends, we have investigated optical waveguides defined within photonic crystal mirrors. We again use the ICP-RIE to define such nanostructures, and Figure 2 shows SEM micrographs of photonic crystal waveguides defined within silicon on insulator (SOI) material. In this case, the single crystal layer of silicon is used to guide the light within the slab, and the perforations on both sides of the waveguide show the photonic crystal mirrors. Again, the etching quality of the holes defined through the silicon slab is excellent, providing high quality optical performance of these waveguides.



Quantum Dot Photonic Crystal Cavities



The combination of a very narrow linewith source with a high Q optical nanocavity is expected to lead to the demonstration of "strong coupling" between the cavity and the emitter. We use quantum dots as the emitters, which emit with a very narrow linewidth at low temperatures. Since the quantum dot material has very little optical gain, it is necessary to define high Q optical cavities to define lasers in this materials system. The high quality of the ICP-RIE etching system obtained with this project has allowed us to demonstrate high quality cavities which are optimally suited to observe nonlinear effects and define ultra-low threshold electrically pumped lasers in this material system.