CRYSTAL WAVEGUIDE LASERS, LIQUID EPITAXY AND ION-IMPLANTATION

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Fabricating low loss planar waveguides in crystal laser hosts can lead to very large inversion densities for relatively low pump powers due to the confinement of light to small dimensions over longer lengths than normally allowed by diffraction. Thus very high gain per unit pump power amplifiers and very low threshold lasers are made possible. Planar waveguides also allow easy access to the guided wave which can be useful for integrated functions (gratings, modulators etc) and good heat removal in high power devices. Here two methods of producing planar waveguide lasers in a variety of interesting host crystals are discussed.

Ion-implantation has been used to make planar waveguides in a wide range of materials and consequently lasers have been demonstrated in YAG, GGG, YAP, $LiNbO_3$, BGO and lead germanate glass waveguides doped with Nd^{3+}, Tm^{3+} and Yb^{3+}. Channel waveguide lasers have also been fabricated by this method using a photolithographically patterned ion-stopping mask. Propagation losses as low as 0.15 dB/cm are reported.

Liquid-phase epitaxial (LPE) growth has been used to produce waveguide lasers in YAG doped with Nd^{3+}, Yb^{3+}, Tm^{3+}, and Yb^{3+}/Er^{3+}. Very low propagation losses of less than 0.05dB/cm have been found in these thin films. LPE growth allows easy control of the guide depth over a wide range (from 3μm to 120μm has been demonstrated). The index difference between the core and substrate can be controlled by doping the core region with index rises of up to $4.8\text{x}10^{-2}$ being observed for Ga/Lu doping. LPE growth also allows production of cladding layers by the same method. Extension of these promising results to channel waveguide geometries and other laser hosts is in progress.

The planar waveguide geometry is also compatible with diode-bar side-pumping. Due to the ease of control of guide depth, index-difference, and possible multi-layer growth, LPE may allow direct butting of diode-bars or a cladding pumped scheme. Both would allow an easing of the difficult focusing problems associated with diode-bars and the waveguide confinement should again allow very high gains per unit pump power. In this way efficient high average power waveguide devices are also envisaged.