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Pulsed laser deposited crystalline optical waveguides for thin-film lasing devices

We have used the technique of pulsed laser deposition (PLD) to grow doped crystalline films of garnets (YAG) and sesquioxdes (Y_2O_3, Sc_2O_3, and Lu_2O_3) for application as optically-pumped waveguide lasers. For the sesquioxides in particular, PLD offers a real advantage in terms of the ~1100K growth temperature required to grow crystalline thin films in comparison to ~2750K required to grow bulk crystals. We can grow these materials at the rate of ~4 µm per hour, on cheap and readily available single-crystal YAG substrates, which allows rapid production of waveguide samples of the ~10-20 µm thickness required for efficient pumping via high-power diode lasers.

The sesquioxide films grow preferentially in the (222) crystal orientation, and although there is an excellent lattice match to the (100) oriented YAG substrates, the four-fold symmetry associated with the (222) growth direction can lead to the presence of domain boundary problems that contribute to an undesirable optical loss within these waveguide hosts. In contrast the garnet hosts experience ideal epitaxial growth (i.e. YAG films grown on YAG substrates) where the presence of the dopant lasing ion produces the necessary refractive index requirement for waveguide operation.

We will discuss the range of lasing results we have achieved so far, which includes c.w. lasing within single waveguide films, capped layers and multilayer structures where the doped lasing layer has been grown within a 3-layer sandwich structure [1,2]. We will also describe results where a single layer of graphene has been deposited on either the output coupler mirror, or on the top surface of the guide, to produce pulsed laser output in q-switched mode [3-4]. Since these lasing waveguides are optically pumped by diode lasers, it is important to design these guiding structures to ensure efficient operation in terms of low threshold and high slope efficiency. Details will be given on optimum waveguide design as well as our strategy on further reduction of optical propagation losses.

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