Optically-pumped ultraviolet microdisk laser on a silicon substrate

W. Fang, X. Liu, Y. Huang, X. H. Wu, S. T. Ho, R. P. H. Chang, H. Cao
Materials Research Center, Northwestern University, Evanston, IL 60208

Abstract: Ultraviolet microdisks lasers are fabricated on silicon substrates, with a thin layer of zinc oxide grown on top of silica disk. Under optical pumping, lasing occurs in the whispering gallery modes at room temperature.

OCIS codes: (140.5960) Semiconductor lasers; (140.3610) Lasers, ultraviolet

As optoelectronics becomes increasingly important for information and communication technologies, there is a need to develop optoelectronic devices that can be integrated with standard silicon microelectronics. There has been much progress in silicon-based passive optoelectronic devices and light emitting diodes, though, a silicon-based laser has not yet been realized. We take a different approach in fabricating silicon-based laser: instead of extracting optical gain from silicon, we grow other gain materials on top of silicon substrates. In this paper, we demonstrated hybrid zinc oxide / silicon dioxide (ZnO/SiO_2) microdisk lasers on silicon substrates. We utilize the silica microdisk as high-quality resonator [1] and ZnO thin film grown on top of silica as gain medium [2].

The silica microdisks are fabricated on a commercial silicon wafer with 230 nm thick SiO_2 layer on the top. Disk patterns are first defined by optical lithography, then transferred to SiO_2 layer by reactive ion etching (RIE). A selective wet etching of silicon by tetramethylammonium hydroxide (TMAH) solution is followed and the Si pedestal is formed underneath each SiO2 disk. Finally, a 55nm ZnO film is grown on top of the disks as gain medium by metalorganic chemical vapor deposition (MOCVD). Figure 1 is the scanning electron microscopy (SEM) of a SiO2 microdisk before and after the ZnO growth.

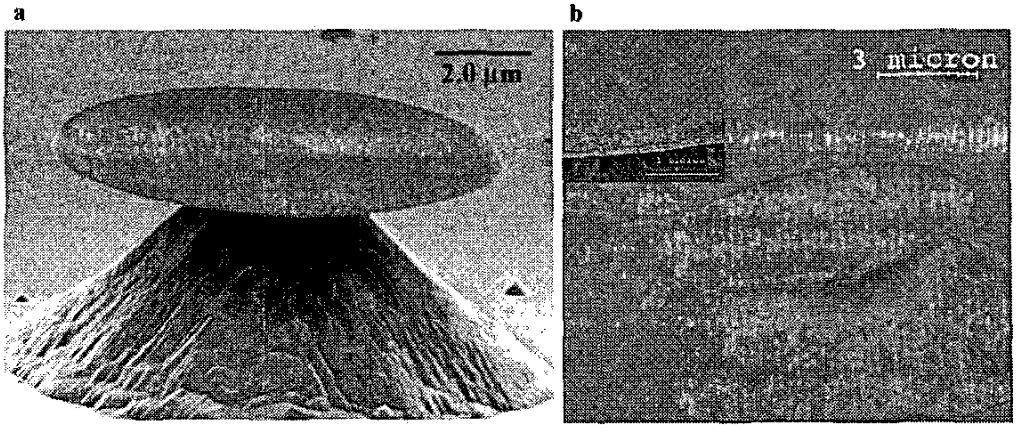

Fig. 1. SEM image of a microdisk of diameter 10 μm, (a) before the deposition of ZnO; and (b) after the deposition. A close view in inset shows the disk is uniformly covered by ZnO nanocrystals.

The hybrid ZnO/SiO_2 microdisk is optically pumped by the third harmonics of a mode-locked Nd:YAG laser at room temperature. A microscope objective lens is used to focus the pump beam onto a single disk. Emission from the disk is collected by the same lens. Figure 2 (a) shows a typical spectrum of emission from a 10μm disk at high pumping intensity. Several sharp peaks can be seen, which are identified as whispering gallery (WG) modes. Emission intensity from one WG mode shows a dramatic increasing above a pumping threshold [figure 2 (b)]. This indicates that lasing occurs in this hybrid microdisk.

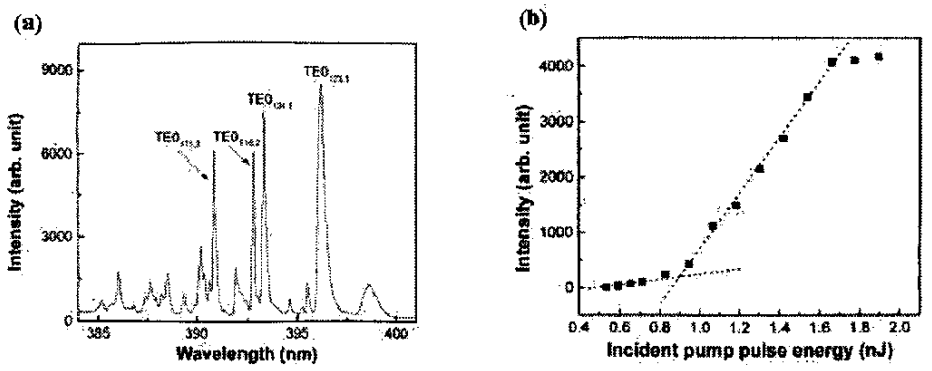

Fig. 2. (a) Typical emission spectrum from a 10 μm disk. (b) Spectrally-integrated emission intensity of a WG versus incident pump pulse energy.

Reference:

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