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Development of materials integration for photonic materials and applications

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Abstract

A study of the fundamental issues of materials integration for wafer bonding offers new pathways for achieving photonic materials with unique properties.

First, the bonding of single crystal oxide crystals (YAG and yttria, for example) with different compositions and even different orientations is shown to critically depend upon several important parameters. A detectable level of subsurface damage usually accompanies the polishing of these crystals. We studied chemical mechanical polishing (CMP) of these oxide crystals to provide surfaces which exhibit sub-nm roughness, and the absence of subsurface damage. These surfaces are then activated and we use XPS and other surface sensitive techniques to assess the state of the surface after different processes. Next, we demonstrate that we can significantly reduce the bonding time and temperature to attach two single crystal pieces based on these improved polishing techniques. These techniques also apply to polycrystalline (ceramic) materials as well.

Second, a controlled variation in laser gain media can be achieved using a combination of wafer bonding and dopant ion implantation. We demonstrate the steps necessary to bond, for example, thin slabs of ZnSe which have been implanted with different doses of Cr. Upon bonding (after the appropriate CMP of the ZnSe surfaces) and subsequent annealing, these structures can exhibit controlled levels of for example, Cr+ without the excessive annealing associated with transition metal doping of bulk substrates.

These examples shed light on new directions in the use of materials integration for photonic crystals.

Biography

Mark Goorsky is a Professor of Materials Science and Engineering at UCLA. He was chair of the department from 2004-2009. He received his Ph.D. in Materials Science and Engineering in 1989 from the Massachusetts Institute of Technology, and his B.S. in Materials Science and Engineering in 1984 from Northwestern University.

Goorsky held a post-doctoral position at the IBM Thomas J. Watson Research Center (Jan. 1989 - June 1991) and started at UCLA in 1991.

He is an associate editor of the Journal of Crystal Growth. He is also a member of the United States Air Force Scientific Advisory Board, which assesses the state of research and development in technologies that are crucial to the Air Force and provides forecasts of long-range science and technology. He was awarded the T.S. Walton Award from the Science Foundation of Ireland in 2010. He also received the TRW Outstanding Young Teacher Award in the School of Engineering and Applied Science in 1993, the National Science Foundation CAREER Award in 1995, and the Northrop Grumman Outstanding Young Researcher Award in 1996.

His research focuses on materials integration and the relationship between materials defects and device performance in semiconductor structures.