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Nano-scale approaches for controlling dielectric thin films for photonic waveguide engineering using ultrafast pulsed lasers – a novel approach for non-clean room fabrication!

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Abstract

Over the last 25 years has seen an unprecedented increase in the growth of phonic components based on semiconductor lasers, glass and polymer based optical fibres, and organic LED, and solid state lasers. Each of these components suffers from its intrinsic materials related limitations which then limit the performance of integrated devices.

A solution to the materials limitation is to develop device fabrication strategy which then allows multi-materials processing on a substrate, without compromising the structural, thermal, and spectroscopic performances. The challenge then one confronts is that the semiconductors are grown on an MBE machine, whereas the polymeric thin film materials are fabricated by traditional spin coating. By comparison, the glass and crystal based materials are processed via sputtering, or sol-gel techniques. None of these techniques, therefore, are compatible for a single step device fabrication, due to chemical and physical incompatibilities of different materials. A vast majority of rare-earth ion doped glass- and crystal- based devices are often pumped with semiconductor lasers, which then suggests that the glass-semiconductor devices might perform better when structurally integrated, and that engineering such structures might lead to reduction in pump power, leading to high photon-to-photon conversion.

In this invited lecture, the importance of nano and femto-second pulsed lasers is demonstrated by showing the examples of multi-material deposition using different materials targets. The modelling tools are used *a priori* for waveguide engineering for ascertaining the extent to which the structural incompatibility due to mismatch strain can be minimized. The structure and spectroscopic properties of rare-earth ion doped thin films on silica, polymer, and semiconductor GaAs substrates were examined in detail and will be reported. We demonstrate the formation of glass-polymer superlattice structures, immiscible glass waveguide structures, nano-silicon deposited waveguides for semiconductor integration.

The machining properties of such composite structures using femto-second Ti-sapphire lasers is also described, which clearly shows that such complex structures from start-to-finish can be fabricated using different types of pulsed lasers without the need of expensive clean room facilities. The amplified spontaneous emission and gain properties of such waveguides are characterized for a range of device applications and will be discussed.

Biography

Animesh Jha is a Materials Scientist, specializing in the area of inorganic photonic materials based on glass, glass-ceramics, and crystals. He obtained his PhD degree from the Imperial College of Science and Technology in 1984. After 3 years of postdoctoral research at the University of Sheffield between 1986 and 1989, he joined Brunel University in UK as a lecturer in May 1989. In March 1996, he was appointed as a Reader at the University of Leeds in the School of Materials, where he became full-time professor in August 2000.

At the University of Leeds, Prof Jha's main interests are in the fundamentals of glass science, thin film structures, laser-matter interaction and engineering novel materials for device applications, and interaction of lasers with biological molecules. He has supervised over 20 Postgraduate (PhD and M Phil) students, published over 230 papers on rare-earth doped glass, glass-ceramics, and devices. In 2005 and 2010, he was awarded the Fellowship of the Society of Glass Technology and the Institute of Physics, respectively. Prof. Jha has memberships of OSA, IEEE, IoP and The Metals Society.

He has won the Department of Trade & Industry's SMART and SMART Development awards for Er-doped Glass Engineering for Broadband Amplifiers, Yorkshire Concept Award for Laser Gain Materials Engineering, and the Research council's Basic Technology Award for Glass-on-Semiconductor Integration.