Thursday Afternoon, November 7, 2002

Photonic Materials Topical Conference
Room: C-111 - Session PH-ThA

Optical Lightguides
Moderator: S. Shankar, Intel

2:00pm **PH-ThA1 Tunable Microfluidic Optical Systems**, ***J.A. Rogers***, Bell Laboratories, Lucent Technologies **INVITED**

This talk describes some of our recent work on pumped microfluidic networks for new classes of dynamically tunable fiber and integrated optical components. It presents two different types of devices. The first combines microstructured, or "holey", silica fiber with microfluidic plugs that can be tuned and pumped back and forth in the fiber using thermal pumps formed directly on the fiber surface.[1] We present two examples of devices that use this microfluidic optical fiber design. One relies on dual-fluid plugs and long period fiber gratings; this component provides variable, wavelength-tunable attenuation for dynamic gain equalization in wavelength division multiplexed optical networks. The other uses fiber tapers; it provides a broadband variable attenuator that can be useful at add/drop nodes. The second class of system combines electrowetting pumps and recirculating planar microfluidic channels with fiber and integrated optical structures. We describe the fluidic and optical physics of these devices, and we demonstrate the performance of several different components that use this design.[2]

[1] P. Mach, C. Kerbage, M. Dolinski, K.W. Baldwin, R.S. Windeler, B.J. Eggleton, J.A. Rogers, "Tunable Microfluidic Optical Fiber," Applied Physics Letters, in press.
[2] P. Mach, T. Krupenkin, S. Yang, J.A. Rogers, "Dynamic Tuning of Optical Waveguides with Electrowetting Pumps and Recirculating Fluid Channels," Applied Physics Letters, submitted.

3:00pm **PH-ThA4 A New Generation of Plastic Optical Fiber**, ***W.R. White***, *L.L. Blyler, R. Ratnagiri*, OFS Laboratories **INVITED**

During the last few years, there have been revolutionary advances in plastic optical fiber (POF) technology as a result of fibers based on perfluorinated polymers, especially poly(perfluorobutenylvinylether), commercially known as CYTOP.[1,2] Due to these new materials, the attenuation obtainable in POF has plummeted from 160 dB/km to less than 20 dB/km, and wide transmission windows have been opened in the commercially desirable wavelength range between 850 and 1300 nm. Moreover, graded-index POF(GI-POF) has been shown[3,4] to have unexpectedly large bandwidths, due to subtle interplay between low material dispersion,[4,5] high mode coupling,[4,5] and differential mode attenuation.[6] How can the remarkable properties of perfluorinated GI-POF be harnessed to deliver an extremely simple, longer reach, high bandwidth medium? To meet this goal, perfluorinated GI-POF must offer aspects of both older POF technologies and silica fiber technologies. From the POF tradition, it is important to retain simplicity of fiber termination and connector attachment. From the silica fiber tradition, we must replicate not only low attenuation and high bandwidths, but also low loss connectors and sophisticated cable designs. In this talk, I will discuss some highlights of our work to develop practical technologies for fabricating, cabling, terminating, and connectorizing perfluorinated GI-POF.

[1] Y. Koike, Proceedings of ECOC '96, v.1 p.141 (1996).
[2] K. Koganezawa and T. Onishi, Proceedings of POF Conference 2000, p.19 (2000).
[3] G. Giaretta, W.R. White, M. Wegmuller, and T. Onishi, IEEE Photonics Tech. Lett., v.12, p.347 (2000).
[4] G. Giaretta, et al, Proceedings of ECOC '99 (1999)
[5] W. R. White, M. Dueser, W. A. Reed, and T. Onishi, IEEE Photonics Tech. Lett., v.11 p.997 (1999).
[6] T. Ishigure and Y. Koike, Proceedings of POF Conference 2000, p.14 (2000).

4:20pm **PH-ThA8 Influence of Ge Content and Process Parameters on the Optical Quality of Low Temperature PECVD Deposited Silica Waveguides**, ***M. Dainese***, *L. Wosinski, H. Fernando, X. Cao*, Royal Institute of Technology, Sweden

Silica-on-Silicon technology for Planar Lightwave Circuits, based on Plasma-CVD, is a candidate for monolithic optoelectronic integration due to its potential compatibility with VLSI technology. But the standard fabrication process, that includes a final high temperature (≥1000°) consolidation step, is not compatible with this purpose. We propose a modified, full low temperature, PECVD-based process that has been optimized to obtain an as-deposited material with high optical quality. Using a capacitively coupled reactor, with 380kHz RF power supply and platen temperatures between 250° and 300°, we have investigated the properties of the as-deposited material, with emphasis on germanium doped silica glass, which forms the light guiding layer. The set of characterisation techniques includes: prism coupler, wet etch rate, FTIR, XPS, ERDA. The results show that, for pure silica, stoichiometry is controlled by the N_2O/SiH_4 flow ratio, whereas RF power affects the material structure and homogeneity, together with by-products release during surface processes. For a given SiH_4 flow and flow ratio, there is an optimum value for the deposition pressure which maximise the deposition rate (here 1750Å/min). In case of germanium doping (up to 6.5at%), the high reactivity and low surface mobility of germane radicals make the deposition more sensitive to platen temperature and produce films with higher porosity and co-ordination disorder, compared to pure silica. We demonstrate that increasing the flow ratio is not enough anymore to obtain correct stoichiometry and RF power becomes a critical variable with respect to this. The final result is a material with low optical losses (0.3dB/cm at 1.55µm), with no absorption due to higher order harmonics of either Si-H or N-H bond vibrations. Examples of photonic devices will be presented.

4:40pm **PH-ThA9 High Density Plasma Enhanced Chemical Vapor Deposition of SiOxNy for Optical Applications: Influence of Process Parameters**, ***P. Bulkin***, *D. Daineka, G. Girard, J.-E. Bourée, B. Drévillon*, CNRS, Ecole Polytechnique, France

Rapid development of integrated optics made necessary the development of the technology for fast deposition of high quality optical films that can be used as a base for waveguide fabrication. Such process shall not only produce silica films with low scattering and absorption in the communication window (1.3-1.6 microns) but also allow doping of the silica in order to create graded refractive index profiles and, maybe even convert it to active media. High-density plasma sources for PECVD, such as ECR, helicons and inductively coupled sources, are prime candidates considered for those applications. However, a process window for high density PECVD needs to be optimised for the deposition of films with thickness of several tens of microns. The deposition systems should also incorporate self-cleaning capabilities. We report in this work on extensive studies of a recently developed matrix distributed electron cyclotron resonance (MDECR) concept for the deposition of silica and silicon oxynitride films. We investigated influence of substrate temperature, microwave power, position and type of gas injection, gas composition and bias on the properties of material grown in such deposition system. Self cleaning by C2F6/O2 plasma was also studied. We show that the MDECR concept can be a technology of choice for the deposition of waveguide structures for integrated optical components.

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