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Optical Switching Systems using Nanostructures

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Abstract:

High capacity multiservice optical networks require compact and efficient switches. The potential benefits of optical switch elements based on nanostructured material are reviewed considering various material systems.

Summary:

Optical switches tend to be relatively bulky due to the large interaction length between photons and material, but more compact switches may be realized as nanostructured materials with enhanced performance emerge. Compact switch fabric is needed as line capacities are steadily increasing and multiservice networks emerge. Moreover, the shift from path switching based on wavelength routing towards burst/packet based routing requires more complex switch fabric with nanosecond switching time.

In view of this development we will review the progress of switching elements using nanostructured material based on combinations of glass, semiconductors and metal and with critical features on the sub-wavelength scale. Regardless of the material system, switching is relying on nonlinear optical processes, e.g. four-wave mixing, or relying on change in refractive index, absorption or gain – sometimes combined with the use of cavities. The state of the switch can be controlled either electronically or optically or in a combination.

Crystal fibers offer an elegant first approach to nanostructured switching elements [1]. With their precisely tailored cross-sections with air holes this type of fiber achieves combinations of nonlinear coefficients and dispersion slope matching enabling more efficient switching elements compared to those made from conventional fiber. Moreover, research focuses on infilling of crystal fibers with other materials such as liquid crystals for high on-off rations or with, e.g., quantum dot material allowing for fast switching.

For higher density of optical functions, planar photonic crystal (PC) structures are explored [2-5]. The field of planar PC structures is in rapid progress and waveguides with relatively low losses have been reported together with solutions for efficient coupling. Much attention is now given to the formation of high-Q nano-cavities that are central for wavelength selective switches, add/drop filters as well as sources. The PC structures with micro/nano-cavities will ultimately enable compact (all-) optical transistors offering functionalities such as gating, wavelength conversion, and logic functions as already known from more bulky devices realized, e.g., using semiconductor optical amplifiers [6]

Ultimately interaction between photons and plasmons in fine structured metal films may be used to realize highly nonlinear switch elements that will be very compact and efficient.

Work on plasmonic optoelectronics is underway with promising results for waveguides and splitters. On a longer term, near field interaction in nano-metric quantum dot structures may lead to switch-elements of sub-wavelength scale [7].

[1] A. Bjarklev, "Photonic crystal fibres and their applications", Proc. of ECOC-IOOC 2003, vol. 5, p 324, Rimini, Italy, Sept. 2003.

[2] R.M. de La Rue, "Photonic crystal and photonic wire devices and technology", Proc. of ECOC-IOOC 2003, vol. 5, p 7, Rimini, Italy, Sept. 2003.

[3] R. Baets, "Nano-photonics" Proc. of ECOC-IOOC 2003, vol. 5, p 200, Rimini, Italy, Sept. 2003.

[4] S. Noda, "Semiconductor photonic Crystals and devices for communications", Proc. of ECOC-IOOC 2003, vol. 5, p 38, Rimini, Italy, Sept. 2003.

[5] A. Scherer et al., Photonic Crystal lasers, Proc. of ECOC-IOOC 2003, vol. 5, p 50, Rimini, Italy, Sept. 2003.

[6] K.E. Stubkjaer, "Semiconductor Optical Amplifier based All-Optical Gates for High-speed Optical Processing", Millenium Issue of Selected Topics in Quantum Electronics, IEEE Journal on , Vol. 6, pp. 1428 –1435, 2000.

[7] M. Ohtsu et al., "Nanophotonics: design, fabrication and operation of nanometric devices using optical near fields", IEEE Jour. On Selected Topics in Quantum Electron., vol. 8, pp 839-862, 2002.