What modern photonics will contribute to the development of the future optical communications technology?

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Optical communications is the linchpin of modern telecommunications; in fact, the vast majority of global telecommunications traffic today is delivered optically. The optical communications industry is one of the largest consumers of electronic products and the trends in developing optical communications will, to a great extent, shape trends in electronics in general and in photonics in particular.

Optical communications today widely spreads in three dimensions: in space, in time and in frequency (spectrum). In space, optical communications stretches from nanometers in optical interconnects to tens of thousands of kilometers in intercontinental links. In time, the optical communications industry operates from kilobits per second in short-reach connections to terabits per second in long-distance links; these bit rates range from milliseconds to picoseconds of the characteristic time. In spectrum, optical communications covers the wavelength band from 850 nm in local communications to 1650 nm in long-haul spans. If this variety and scale of the characteristic numbers is insufficient to stress the complexity of modern optical communications, we must add another factor: the network. The need to deliver information to an individual receiver through a web of connections ranging from chip-level interconnects to the world area network is a herculean task. It involves intelligent firmware system, transmission technology and network management, all of which are being controlled by quite sophisticated software. Optical communications is under constant pressure to improve all aspects of its operations – from the ever-increasing demand for bandwidth to reducing the bit-per-kilometer cost. In responding to these demands, technology has quickly developed many wonderful components, devices, and systems.

But herein lies a problem: since every developer is concerned only with one specific area, the industry lacks an overall body looking into future trends in technology. In the meantime, researchers are accomplishing significant advances in our ability to control and use the new phenomena in technological applications. Thus, the question is which of these new discoveries will be the basis for the next-generation technology? Will today's experiments on single-photon manipulation (generation, modulation and detection) lead to the development of tomorrow's transmitters and receivers? Will silicon-based photonics create new types of communications devices and reduce the cost of optical communications? Will excitons enable further development of optically active integrated circuits? Will supercollimation combined with the use of photonic crystals change the way of transmission in interconnects? Will quantum routers and repeaters alter our approach to networking? Will metamaterials and nanophotonics solve the problem of coupling and packaging? These and many similar questions should be considered at the system level to reasonably predict the future areas of development of optical communications technology.

This paper discusses the modern trends in photonics that would enable the development of new components, devices and systems for the main building blocks – a sending end, networking and transmitting, and a receiving end – of the future fiber-optic communications technology. We also present, from the optical-network point of view, the analysis of the future needs in technology developments.