Highest core density realized with 12-core single-mode optical fiber

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Enterprise networks and data centers continue to increase their demands for connectivity, with ever larger quantities of data expected to be transmitted in the foreseeable future. Over the past 20 years, fiber-optic technology has experienced tremendous success in bringing us a fast, globally-connected internet. Providing greater capacity for information transfer is key to meeting future needs. A recent advancement in fiber core structures promises to help us reach this goal more quickly.

Single-mode optical fibers, where light travels along a single pathway, are quickly approaching capacity limits on today's networks. Research on this topic has focused on adding more transmission pathways within these optical fibers. Multi-mode fibers – whose cores can support the propagation of multiple modes of light – may seem an obvious solution, but suffer from dispersion and limitations over a long-haul network.

Now, researchers are investigating multi-core fiber (MCF) technology, placing multiple single-mode cores within a single optical fiber. Increasing the number of cores within an optical fiber is challenging because adding cores incurs thicker optical fiber diameters, which suffer their own limitations in application.

A research team from NTT Access Network Service Systems Laboratories, Japan, have developed an MCF design, for the first time, with 12 core paths. The cores are then "randomly-coupled" in a way that can transmit larger amounts of data through a standard-sized 125 micrometer diameter fiber. The NTT team will present their findings at the Optical Fiber Communication Conference and Exhibition (OFC), held 19-23 March in Los Angeles, California, USA.

"The 12-core paths in an optical fiber with the standard 125 micrometer cladding is a new achievement in optical networking transmission technology," said NTT research engineer, Taiji Sakamoto. "NTT has invested resources into this new technology for use in transmission systems and data centers. We need to scale our networks to anticipate future bandwidth demands."

But, Sakamoto explained, MCF development has a number of challenges. The first constriction on MCF development is a spatial one. Fibers need to be deployed within limited spaces, like underground ducts, so keeping to standard diameters is a priority.

To keep to size restrictions, the team looked at developing MCF with small core pitches, or spacings, to maximize the number of cores within the fiber. Taking into account the limits on fiber diameters, the NTT researchers employed a coupled core arrangement within the fiber's 125-micrometer cladding. The team was able to put in the casement a total of 12 cores, arranging them with a special twisting of the fibers in a randomly coupled MCF that NTT researchers concluded would enable maximum capacity.

The researchers also explored the geometric arrangement for the cores inside the fiber. Among the three possibilities: a 19-core hexagonal arrangement, a 10-core circular arrangement, and a 12-core square lattice. They concluded that the 12-core square lattice design best optimized the spatial density, while maintaining random mode coupling.

A pressing challenge for the research team is called spatial mode dispersion (SMD), where signals spread in the time domain, making it difficult to realize the real-time DSP which is inevitable for implementing space division multiplexing technology into the real system. Adding core paths within a single fiber increases those challenges. Sakamoto and his team concluded that an MCF with a randomly coupled core arrangement minimizes spatial mode dispersion, resulting in lower a DSP complexity.

"The signal processing complexity caused by the large SMD is a serious problem. Our paper to be presented at OFC will explain how we reduce SMD for MCF with more than 10 cores," Sakamoto added.

According to Sakamoto, the next step is to investigate the scalability of their randomly coupled MCF. If successful, he expects that the technology could be available for large scale markets in about a decade. The group will continue to investigate the maximum number of cores that can be deployed with randomly coupled MCF, while maintaining its key benefit of minimizing spatial mode dispersion and signal processing complexity.

"We saw success with randomly coupled MCF," Sakamoto said. "So the next step is to find out how we can realize more cores while maintaining the random-coupling status resulting in even greater capacity per fiber."

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