Report on OECC 2021 SDM Workshop

1. Introduction
OECC 2021, the 26th Optoelectronics and Communications Conference was held virtually on July 3rd – 7th, 2021 [1] and on July 3rd, 2021, a workshop on the latest SDM (Space-division multiplexing) optical technologies entitled “SDM is beginning to reach its capacity limit? What is a viable path to 100 Pbit/s per fiber and beyond?” was held virtually at 14:00-18:00 (four hours), technically co-sponsored by Technical Committee on Extremely Advanced Optical Transmission Technologies (EXAT), IEICE [2].

Optical fiber communication has been one of the key technologies enabling the growth of the various communication services. However, we are now approaching the capacity limit of present optical communication systems based on single-core, single-mode optical fibers. SDM technologies based on multicore fibers (MCFs) and/or multi-mode fibers (MMFs) have been proposed by EXAT and have attracted a lot of attention as a promising approach to overcome such limit. 10 Pbit/s per fiber transmission has already been demonstrated based on SDM technologies by the EXAT members [3].

In this workshop, novel enabling technologies were discussed from the standpoint of how we can further increase the transmission capacity towards 100 Pbit/s per fiber and beyond, such as MCF/MMF transmission technologies with spatial counts higher than 100, advanced modulation/coding technologies, and ultra-wide-band amplification technologies.

2. Workshop Program
Eight eminent invited speakers from around the world presented their views on the state of the art as well as their future perspectives on the topics ranging from devices (SDM optical fibers, SDM amplifiers, SDM MUX/DEMUX), SDM transmission and node systems, to its applications to data center networks as listed in Table 1. Each talk was 25 min. including 5 min. Q&As.

Table 1  List of invited speakers.

<table>
<thead>
<tr>
<th>Speakers</th>
<th>Affiliation</th>
<th>Title</th>
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<tr>
<td>Chongjin Xie</td>
<td>Alibaba, USA</td>
<td>“Capacity demand of data center networks”</td>
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<tr>
<td>Kazunori Mukasa</td>
<td>Furukawa Electric, Japan</td>
<td>“Technologies to increase the number of cores in a fiber - beyond 100”</td>
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<td>Yusuke Sasaki</td>
<td>Fujikura, Japan</td>
<td>“High density spatial channel fibers, few-mode fibers”</td>
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<td>Yongmin Jung</td>
<td>University of Southampton, UK</td>
<td>“High-density SDM amplifiers”</td>
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<tr>
<td>Joel Carpenter</td>
<td>University of Queensland, Australia</td>
<td>“Laguerre-Gaussian mode sorters of high spatial mode count”</td>
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<td>Georg Rademacher</td>
<td>NICT, Japan</td>
<td>“Ultra-high capacity transmission using SDM”</td>
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<tr>
<td>Yutaka Miyamoto</td>
<td>NTT, Japan</td>
<td>“Ultra-high capacity optical transport using SDM”</td>
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<tr>
<td>Jianjun Yu</td>
<td>Fudan University, China</td>
<td>“Ultra-high level modulation”</td>
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3. Discussion
After eight presentations, a panel discussion was held among invited speakers and three organizers on the following topics, which were answered by relevant speakers.
1. Traffic demands will continue to increase?
2. SDM is beginning to reach its capacity limit per fiber?
   a. What is the important factor? Number of cores/modes or density?
   b. Maximum number of cores and modes for transmission (short reach/long-haul)
   c. Networking perspective, goals
3. What is a viable path to 100 Pbit/s per fiber and beyond?
   a. 100 Pbit/s (>1,000 spatial channels)
   b. Beyond towards 1 Ebit/s (>10,000 spatial channels)
   c. Alternatives to SDM? Combinations with SDM?
   d. Multi-band transmission (O, E, S, C, L, U…) and issues
   e. Higher order modulation formats?

4. Conclusion
Although definite solutions towards 100 Pbit/s transmission were not derived from the workshop, it did raise awareness that we need to cooperate and advance relevant SDM technologies to the forthcoming goal of achieving 100 Pbit/s per fiber transmission very soon.

5. References

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