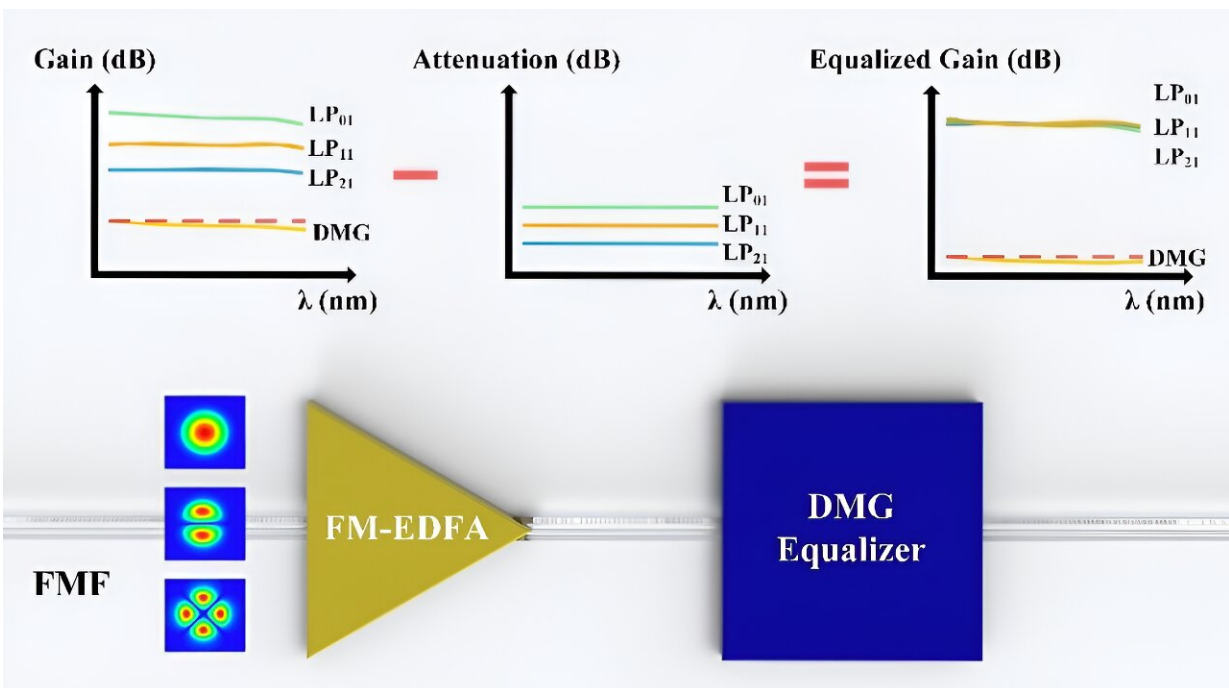


Scientists develop DMG equalization strategy via femtosecond laser micromachining induced refractive index tailoring

August 28 2024



Schematic diagram of differential mode gain equalization strategy for few-mode fiber. Credit: *Light: Advanced Manufacturing* (2024). DOI: 10.37188/lam.2024.014

Optical fiber, as a physical medium for information transmission, is the "highway" of modern economic and social development. However, with the continuous emergence of high-speed and high-capacity

communication scenarios such as virtual reality, 5G, intelligent driving, and the Internet of Things (IoT), there is an upper limit to the communication capacity (traffic flow) of the traditional single-mode fiber-optic communication system (highway).

Mode Division Multiplexing (MDM) technology, which exponentially expands the capacity of communication systems by using multiple mutually orthogonal spatial modes within a few-mode fiber as independent transmission channels, has gained global research attention.

However, differential modal gain (DMG) in the few-mode erbium-doped fiber amplifier (FM-EDFA), due to the different overlapping integrals among the pump mode profile, the erbium doping, and the signal mode profile, limits both the capacity and the reach of MDM transmission.

In a new paper [published](#) in *Light: Advanced Manufacturing*, a team of scientists, led by Professor Yuwen Qin from Key Laboratory of Photonic Technology for Integrated Sensing and Communication, Ministry of Education of China, and co-workers have developed an innovative differential mode gain (DMG) equalization strategy via femtosecond laser micromachining induced refractive index (RI) tailoring.

Based on the precise and controllable RI tailoring, a specific attenuation spectrum can be applied to different guide mode groups according to their gain spectrum, leading to a successful DMG equalization. To verify the feasibility and advantages of the proposed DMG equalization strategy, they investigated a simple-structured and cost-effective FM-EDFA with uniform Erbium doping and fundamental mode core-pumping.

More interestingly, the proposed DMG equalization scheme works very

well even when the guided mode group increases to higher orders. The reported method and technique open a new vision angle to the highly efficient and low-cost DMG equalization scheme in the MDM system.

These scientists summarize the device operation principle as follows, "Simulation results show that, when the pump power and the EDF length vary from 200 mW to 600 mW and 1 m to 7m, DMG within LP01, LP11, and LP21 mode groups varied from 4.8 dB to 16.2 dB occurs. By cascading the DMG equalizer with optimal values of length L and Δn , the DMG_{max} and DMG_{ave} over the C-band can be reduced from 10 dB to 1.52 dB and 8.95 dB to 0.78 dB, respectively.

"A proof-of-concept experiment shows that the DMG_{max} is reduced from 2.09 dB to 0.46 dB, and the DMG_{ave} over the C-band is reduced from 1.64 dB to 0.26 dB. More importantly, the IL induced by the DMG equalization is less than 1.9 dB, indicating that 64% of the pumping power is efficiently utilized. Meanwhile, the proposed DMG equalizer has a maximum equalization range of 5.4 dB, which can satisfy the flexible application of current FM-EDFA."

"Higher-order mode group DMG equalization could be anticipated with more complicated RI modification pattern and higher-resolution [femtosecond laser](#) micromachining technology, which is ideally desirable for future long-haul MDM transmission," the scientists forecast.

More information: Cong Zhang et al, Differential mode-gain equalization via femtosecond laser micromachining-induced refractive index tailoring, *Light: Advanced Manufacturing* (2024). [DOI: 10.37188/lam.2024.014](https://doi.org/10.37188/lam.2024.014)

Provided by Key Laboratory of Photonic Technology for Integrated Sensing and Communication

Citation: Scientists develop DMG equalization strategy via femtosecond laser micromachining induced refractive index tailoring (2024, August 28) retrieved 29 August 2024 from <https://phys.org/news/2024-08-scientists-dmg-equalization-strategy-femtosecond.html>

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