CLAIMS

1. A correction optical element (COE) for a multi-channeled coherent beam combining (CBC) system that uses a fiber array comprising multiple optical fibers and a single collimation array comprising multiple collimating lenses each configured only for collimation of an incoming optical beam, for coherent combining of a corresponding array of optical beams directed through the fiber array,

   wherein each pair of: a collimating lens of the collimation array and a corresponding optical fiber of the fiber array, defines a channel ij,

   wherein the COE is custom-fabricated for segmented correction of optical aberrations of the specific single CBC system by having an array of correction segments, each correction segment CSij in the array of correction segments, being customized in location and configuration to correct specific and premeasured one or more optical aberrations of a corresponding output optical beam Bij outputted from each corresponding pair of a collimation lens Lij and a corresponding optical fiber Fij,

   wherein the COE is configured for customized and segmented correction of collimation-based optical aberrations, caused at least due to misalignments between each corresponding optical fiber's Lij output end and a center of a corresponding collimating lens Lij,

   wherein the correction of the optical aberrations of all channels of the system, is done optically and simultaneously by the COE, and

   wherein the COE is located adjacently to and before or after the collimation array, such that no optical element is placed therebetween that is configured to change beam profile of optical beams.

2. The COE of claim 1, wherein the COE is configured to segmentally correct, for each output optical beam Bij, any one or more optical aberrations of: pointing errors; focusing/collimation errors; wave-front aberrations; high-order three dimensional aberrations, spatial distribution errors; comatic aberrations; field curvature aberrations, cylinder aberrations; smile errors, manufacturing errors, errors in spaces between collimating lenses in the collimation array.

3. The COE of any one or more of claims 1 to 2, wherein segments of the COE are shaped over at least one side of the COE by using one or more of: embossment, curving, sputtering, evaporation, engraving, printing, ion-beam deposition.

4. The COE of any one or more of claims 1 to 3, wherein the COE is made of a monolithic piece being customized to have each correction segment CSij thereof differently custom shaped to correct one or more aberrations of the corresponding output optical beam Bij of the respective channel ij.

5. The COE of any one or more of claims 1 to 4, wherein each segment of the COE comprises one or more wedges, configured for diffractive correction of the optical aberrations of the output optical beam Bij.

6. The COE of any one or more of claims 1 to 5, being further designed for a CBC system in which the optical fibers are connected to an input surface of an endcapping element.

7. The COE of claim 6, wherein the COE is integrally connected or configured over an output surface of the collimation array, the output curved surface comprising lens-shaped curved bulges each bulge having a custom-designed correction embossment or etching, such that each of the optical beams exiting an output surface of the endcapping element are both collimated and corrected.

8. The COE of any one or more of claims 6 to 7, wherein the COE is integrally or non-integrally connected to an input surface of the collimation array, wherein bulges of lenses of the collimation array form the output surface of the COE and custom-shaped correction segments are located over an input surface of the COE, facing an output surface of the endcapping element.

9. The COE of any one or more of claims 6 to 7, wherein the COE is embedded in the collimation array and the endcapping element of the CBC system, forming a single monolithic coherent beam combination, endcapping and correction element by having an output surface of the endcapping element integrally connected to an input surface of the collimation array and an output surface of the collimation array having a correcting 3D design embossed or debossed thereover for performing combined

customized and segmented collimation and aberration correction of each optical beam.

10. The COE of any one or more of claims 1 to 9, wherein the optical fibers of the CBC system are configured for guiding light of a bandwidth ranging from 0.4-2.5μm.

11. The COE of any one or more of claims 1 to 10, wherein the COE is embedded as part of the specific CBC system.

12. The COE of any one or more of claims 1 to 11, wherein the COE is configured for correcting optical aberrations of a multi-channel CBC system using high power fiber lasers or fiber amplifiers.

13. A method for fabricating a correction optical element (COE) for a multi-channel coherent beam combining (CBC) system having an array of channels, using a fiber array, which is an array of optical fibers, an endcapping element connected at an input side thereof to the array of optical fibers and a collimation array comprising multiple collimating lenses each collimating lens being configured only for collimation of an incoming optical beam, for coherent combining of an array of input optical beams outputted by the endcapping element, the method comprising:

measuring one or more optical aberrations Aij of each channel ij of the array of channels of the CBC system, based on measurement of characteristics of a wavefront of each output optical beam Bij of each channel Cij, outputted from a respective lens Lij of the collimation array which is connected to a respective optical fiber Fij;

determining, for each segment CSij of the COE to be fabricated, a required correction design for correcting all measured optical aberrations of the respective correcting segment CSij, for the specific CBC system and for a particular location and positioning of the COE to be fabricated;

fabricating a COE having an array of segments, by configuring each segment of the COE according to its respective required correction design;

placing the COE at a determined positioning for optimal aberrations correction such that each correction segment CSij of the COE is positioned in an optimal positioning in respect to the output optical beam Bij; and

using the COE to simultaneously correct optical aberrations of all segments of the CBC system;

wherein the COE is configured for customized and segmented correction of optical aberrations, caused due to misalignments between a respective optical fiber's output end and a center of a corresponding collimating lenslet Lij of the collimation array of the specific CBC system, and

wherein the COE is located adjacently to and before or after the collimation array, such that no optical element is placed therebetween that is configured to change beam profile of optical beams.

14. The method of claim 13, wherein the COE is configured to segmentally correct one or more optical aberrations, for each output optical beam Bij, of: pointing errors; focusing/collimation errors; wave-front aberrations; high-order three dimensional aberrations, spatial distribution errors; comatic aberrations; field curvature aberrations, cylinder aberrations; smile errors, manufacturing errors, errors in spaces between collimating lenses in the collimation array.

15. The method of any one or more of claims 13 to 14, wherein each of the output beams Bij, measured for determination of its respective one or more aberrations is directed from each optical fiber Fij, through the endcapping element and through a respective lenslet Lij of the collimation array such that the measuring of the optical aberrations of the respective channel ij is done for aberrations detected from segments of a collimated output beam exiting the collimation array of the CBC system.

16. The method of any one or more of claims 13 to 14, wherein each output optical beams Bij, measured for determination of its respective one or more aberrations is directed from a respective optical fiber Fij, through the endcapping element towards a correction input surface of the COE, wherein the collimation array is formed as an output surface of the COE.

17. The method of any one or more of claims 13 to 16, further comprising directing light emanating from a single light source to the fiber array, using one or more optical splitting elements;

18. The method of any one or more of claims 13 to 17, wherein the one or more optical aberrations of each channel ij, for all channels of the CBC system are measured simultaneously or separately channel by channel, using one or more optical detectors and a processing and control unit, configured to receive and analyze output data outputted by the one or more optical detectors, in order to determine required correction for each channel ij of the CBC system.

19. The method of claim 18, wherein the one or more optical detectors comprise one or more of: a camera, a charged coupled device (CCD), an array of photodiodes or photo detectors, MxN photo detectors each coupled to a different focusing lens or lenslet for separately measuring optical characteristics including the one or more optical aberrations for each channel ij.

20. The method of any one or more of claims 13 to 19, wherein the COE is configured to be essentially positioned in parallel to the collimation array.

21. The method of any one or more of claims 18 to 20, wherein each correction segment CSij design is determined by measuring one or more wavefront characteristics of each beam Bij using the one or more optical detectors and generating a three-dimensional model of the correction segment CSij of the respective channel ij, based on the wavefront characteristics.

22. The method of claim 21, wherein the 3D design of each correction segment CSij is a 3D mirror image of the wavefront of the beam Bij of the corresponding channel ij.

23. A system for coherent beam combining (CBC) comprising at least:

- at least one light source for irradiating light in a narrow wavelength band;

- a fiber array, which is an array of optical fibers configured to guide light emanating from the at least one light source forming an array of input optical beams;

- a collimation array, which is an array of collimating lenses, each collimating lens being configured only for collimation of an incoming optical beam; and

- a correction optical element (COE) that is customized for segmented correction of optical aberrations of the specific CBC system, the COE comprising an array of correction segments, each correction segment CSij being configured to correct specific and premeasured one or more optical aberrations of a corresponding output beam Bij emanating from a corresponding optical fiber Fij of a respective ij channel,

wherein the COE is configured for customized and segmented correction of optical aberrations, caused at least due to misalignments between a respective optical fiber's output end and a center of a corresponding collimating lens Lij of the collimation array of the specific CBC system,

wherein the correction of optical aberrations of all channels is done optically and simultaneously, and

wherein the COE is located adjacently to and before or after the collimation array, such that no optical element is placed therebetween that is configured to change beam profile of optical beams.

24. The CBC system of claim 23 further comprising an endcapping element connected, at an input surface of the endcapping element, to output ends of the fiber array such that each optical beam exiting from each optical fiber Fij, exits from a corresponding segment of an output surface of the endcapping element.

25. The CBC system of any one or more of claims 23 to 24 further comprising:

one or more optical detectors located and configured to detect optical characteristics of a coherently combined output beam that has been combined by the collimation array and corrected by the COE;

a processing and control subsystem (PCS), configured to receive output data from the one or more optical detectors and analyze the received output data to measure one or more CBC system performances characteristics.

26. The CBC system of claim 25 further comprising a synchronization module for synchronizing phase and/or polarization of each channel ij such that all phases and/or polarizations of all channels are synchronized, using corresponding a phase synchronization module including an array of phase shifters and/or a polarization synchronization module including an array of polarization controllers.

27. The CBC system of any one or more of claims 23 to 26, wherein the COE is configured to segmentally correct any one or more of the following optical aberrations for each output optical beam Bij: pointing errors; focusing/collimation errors; wave-front aberrations; high-order three dimensional aberrations, spatial distribution errors; comatic aberrations; field curvature aberrations, cylinder aberrations; smile errors.

28. The CBC system of any one or more of claims 23 to 27, wherein segments of the COE are shaped over at least one side of the COE by using one or more of the following techniques: embossment, curving, sputtering, evaporation, engraving, printing, ion-beam deposition.

29. The CBC system of any one or more of claims 23 to 27, wherein the COE is made of a monolithic piece being customized to have each correction segment CSij thereof differently custom shaped to correct a respective aberration of the corresponding optical beam Bij of the respective channel ij.

30. The CBC system of any one or more of claims 23 to 29, wherein each segment of the COE comprises one or more wedges, configured for diffractive correction of the optical aberrations of the respective output optical beam Bij.

31. The CBC system of any one or more of claims 23 to 30, wherein the COE is integrally connected or configured over an output surface of the collimation array, the output curved surface comprising an array of lens-shaped curved bulges each bulge having a custom designed correction addition, such that each of the optical beams exiting an output surface of the endcapping element are collimated and corrected by the COE.

32. The CBC system of any one or more of claims 23 to 31, wherein the COE is integrally or non-integrally connected to an input surface of the collimation array, wherein bulges of lenses of the collimation array form the output surface of the COE and custom-shaped correction segments are located over an input surface of the COE, facing an output surface of the endcapping element.

33. The CBC system of any one or more of claims 23 to 32, wherein the COE is embedded in the collimation array and an endcapping element of the CBC system, forming a monolithic coherent beam combination, endcapping and correction element by having an output surface of the endcapping element integrally connected to an input surface of the collimation array and an output surface of the collimation array having a correcting 3D design embossed or debossed thereover for performing combined customized and segmented collimation and aberration correction of each optical beam.

34. The COE of any one or more of claims 23 to 33, wherein the optical fibers of the CBC system are configured for guiding therethrough light of a wavelength bandwidth ranging from 0.4-2.5μm.

35. The CBC system of any one or more of claims 23 to 34, wherein the COE is configured for correcting aberrations of a multi-channel CBC system using an array of high power fiber lasers or fiber amplifiers.