CLAIMS:

1. A broadband mid-infrared optical parametric amplifier comprising:

a broadband beam combiner configured to direct a collinear combined beam comprising a mid-infrared pump beam and a mid-infrared signal beam to a Gallium Selenide (GaSe) substrate, wherein the combiner comprises a first Silicon wafer oriented at Brewster's angle with respect to the mid-infrared pump beam and the mid-infrared signal beam;

the GaSe substrate being aligned such that an external phase-matching angle is formed between the mid-infrared pump beam incident on a surface of the GaAs substrate and an optical axis of the GaSe substrate and the GaSe substrate being rotated such that a phase-matching azimuthal angle is formed between the mid-infrared pump beam and a crystal axis of the GaSe substrate; and

a broadband beam splitter configured to split a combined mid-infrared output beam received from the GaSe substrate into a broadband mid-infrared idler beam and a mid-infrared residual beam, wherein the splitter comprises a second Silicon wafer oriented at Brewster's angle with respect to the combined mid-infrared output beam and the broadband mid-infrared idler beam.

2. The amplifier according to claim 1 wherein the external phase-matching angle is between 30° and 32° and the phase-matching azimuthal angle is between 29° and 31°.

3. The amplifier according to claim 2 wherein an internal phase-matching angle between 10.5° and 12.5° is formed when the external phase-matching angle is between 30° and 32°.

4. The amplifier according to claim 1 wherein the external phase-matching angle is about 30.6°, the phase-matching azimuthal angle is about 30° and the mid-infrared pump beam has a wavelength about 2100nm.

5. The amplifier according to claim 1 whereby the first and second Silicon wafers have a thickness about 300 μm.

6. The amplifier according to any one of claims 1 to 5 whereby the GaSe substrate has a thickness between 0.1 and 2 mm.

7. A method of generating a broadband mid-infrared idler beam using a broadband beam combiner, a Gallium Selenide (GaSe) substrate and a broadband beam splitter that are configured as a mid-infrared optical parametric amplifier, the method comprising:

directing, using the broadband beam combiner, a collinear combined beam comprising a mid-infrared pump beam and a mid-infrared signal beam to the GaSe substrate, wherein the combiner comprises a first Silicon wafer oriented at Brewster's angle with respect to the mid-infrared pump beam and the mid-infrared signal beam;

mixing, using the GaSe substrate, the mid-infrared pump beam and the mid-infrared signal beam, whereby the GaSe substrate is aligned such that an external phase-matching angle is formed between the mid-infrared pump beam incident on a surface of the GaAs substrate and an optical axis of the GaSe substrate and the GaSe substrate is rotated such that a phase-matching azimuthal angle is formed between the mid-infrared pump beam and a crystal axis of the GaSe substrate; and

splitting, using the broadband beam splitter, a combined mid-infrared output beam received from the GaSe substrate into the broadband mid-infrared idler beam and a mid-infrared residual beam, wherein the splitter comprises a second Silicon wafer oriented at Brewster's angle with respect to the combined mid-infrared output beam and the broadband mid-infrared idler beam.

8. The method according to claim 7 wherein the external phase-matching angle is between 30° and 32° and the phase-matching azimuthal angle is between 29° and 31°.

9. The method according to claim 8 wherein an internal phase-matching angle between 10.5° and 12.5° is formed when the external phase-matching angle is between 30° and 32°.

10. The method according to claim 8 wherein the external phase-matching angle is about 30.6°, the phase-matching azimuthal angle is about 30° and the mid-infrared pump beam has a wavelength about 2100nm.

11. The method according to claim 7 whereby the first and second Silicon wafers have a thickness about 300 μm.

12. The method according to any one of claims 7 to 11 whereby the GaSe substrate has a thickness between 0.1 and 2 mm.