SUMMARY

[9] One non-limiting and exemplary embodiment facilitates providing communication apparatuses and methods for enhancing UL transmission with multiple beams.

[10] In an aspect, the present disclosure provides a communication apparatus comprising: a transceiver, which in operation, receives control information indicating two or more uplink transmission spatial filters for uplink transmissions; and circuitry, which in operation, uses the two or more uplink transmission spatial filters for a plurality of uplink transmission occasions based on the control information, wherein for codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a first transmit precoding matrix indicator (TPMI) and a first sounding reference signal resource indicator (SRI) in the control information, and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a second TPMI and a second SRI in the control information, and/or for non-codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a first non-zero-power channel state information reference signal (NZP CSI-RS), and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a second NZP CSI-RS.

[11] In an aspect, the present disclosure provides a communication method, comprising: receiving control information indicating two or more uplink transmission spatial filters for uplink transmissions; and using the two or more uplink transmission spatial filters for a plurality of uplink transmission occasions based on the control information, wherein for codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a first transmit precoding matrix indicator (TPMI) and a first sounding reference signal resource indicator (SRI) in the control information, and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a second TPMI and a second SRI in the control information, and/or for non-codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a first non-zero-power channel state information reference signal (NZP CSI-RS), and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a second NZP CSI-RS.

[11a] In an aspect, the present disclosure provides a base communication apparatus , comprising: circuitry, which, in operation, generates control information indicating two or more uplink transmission spatial filters for uplink transmissions; and a transmitter, which, in operation, transmits the control information, wherein for codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a first transmit precoding matrix indicator (TPMI) and a first sounding reference signal resource indicator (SRI) in the control information, and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a second TPMI and a second SRI in the control information, and/or for non-codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a first non-zero-power channel state information reference signal (NZP CSI-RS), and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a second NZP CSI-RS.

[11b] In an aspect, the present disclosure provides a communication method comprising: generating control information indicating two or more uplink transmission spatial filters for uplink transmissions; and transmitting the control

information, wherein for codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a first transmit precoding matrix indicator (TPMI) and a first sounding reference signal resource indicator (SRI) in the control information, and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a second TPMI and a second SRI in the control information, and/or for non-codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a first non-zero-power channel state information reference signal (NZP CSI-RS), and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a second NZP CSI-RS.

[11c] In an aspect, the present disclosure provides an integrated circuit configured to control a process of a communication apparatus, the process comprising: receiving control information indicating two or more uplink transmission spatial filters for uplink transmissions; and using the two or more uplink transmission spatial filters for a plurality of uplink transmission occasions based on the control information, wherein for codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a first transmit precoding matrix indicator (TPMI) and a first sounding reference signal resource indicator (SRI) in the control information, and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a second TPMI and a second SRI in the control information, and/or for non-codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a first non-zero-power channel state information reference signal (NZP CSI-RS), and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a second NZP CSI-RS.

[11d] In an aspect, the present disclosure provides an integrated circuit configured to control a process of a base communication apparatus, the process comprising: generating control information indicating two or more uplink transmission spatial filters for uplink transmissions; and transmitting the control information, wherein for codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a first transmit precoding matrix indicator (TPMI) and a first sounding reference signal resource indicator (SRI) in the control information, and a second uplink

transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a second TPMI and a second SRI in the control information, and/or for non-codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a first non-zero-power channel state information reference signal (NZP CSI-RS), and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a second NZP CSI-RS.

[12] It should be noted that general or specific embodiments may be implemented as a system, a method, an integrated circuit, a computer program, a storage medium, or any selective combination thereof.

[13] Additional benefits and advantages of the disclosed embodiments will become apparent from the specification and drawings. The benefits and/or advantages may be individually obtained by the various embodiments and features of the specification and drawings, which need not all be provided in order to obtain one or more of such benefits and/or advantages.

CLAIMS

1. A communication apparatus, comprising:

a transceiver, which, in operation, receives control information indicating two or more uplink transmission spatial filters for uplink transmissions; and

circuitry, which, in operation, uses the two or more uplink transmission spatial filters for a plurality of uplink transmission occasions based on the control information, wherein

for codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a first transmit precoding matrix indicator (TPMI) and a first sounding reference signal resource indicator (SRI) in the control information, and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a second TPMI and a second SRI in the control information, and/or

for non-codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a first non-zero-power channel state information reference signal (NZP CSI-RS), and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a second NZP CSI-RS.

2. The communication apparatus of claim 1, wherein the plurality of uplink transmission occasions include one or more of a physical uplink control channel (PUCCH), a physical uplink shared channel (PUSCH) processing from one or more transport blocks, a sounding reference signal (SRS), or a physical random access (PRACH) transmission occasion, and are defined by a slot index, a starting symbol, and a number of consecutive symbols.

3. The communication apparatus of claim 1, wherein the plurality of uplink transmission occasions are transmission occasions among a plurality of repetitions of a physical uplink control channel (PUCCH) or a physical uplink shared channel (PUSCH) in an inter-slot level repetition framework, or transmission occasions among a plurality of nominal/actual repetitions of the PUCCH or the PUSCH in an intra-slot level repetition framework.

4. The communication apparatus of claim 1, wherein the transceiver, in operation, receives an explicit indication of performing the beam switching in a time-domain from

a base communication apparatus, wherein the at least one condition for beam switching is based on the explicit indication.

5. The communication apparatus of claim 1, wherein the transceiver, in operation, receives the control information by using at least one of a downlink control information (DCI) signaling, a medium access control layer control element (MAC CE) signaling, or a radio resource control (RRC) signaling.

6. The communication apparatus of claim 1, wherein the at least one condition is that a first interval between two consecutive uplink transmission occasions of the plurality of uplink transmission occasions is not less than a required latency of beam switching.

7. The communication apparatus of claim 6, wherein the beam switching is performed within a cyclic prefix in case the required latency of beam switching is not greater than a duration of the cyclic prefix.

8. The communication apparatus of claim 1, wherein the circuity, in operation, provides assistance information to a base communication apparatus based on capabilities of the two or more uplink transmission spatial filters.

9. The communication apparatus of claim 1, wherein the circuitry, in operation, uses the two or more uplink transmission spatial filters for the plurality of uplink transmission occasions in a cyclical or a sequential pattern.

10. The communication apparatus of claim 1, wherein the circuitry, in operation, associates the two or more uplink transmission spatial filters with a plurality of transmission configuration indicator (TCI) states.

11. The communication apparatus of claim 1, wherein the two or more uplink transmission spatial filters are configured with a set of power control parameters.

12. The communication apparatus of claim 1, wherein the circuitry, in operation, associates the two or more uplink transmission spatial filters with at least one of a

plurality of transmit precoders from a codebook for codebook-based transmission based on the control information.

13. The communication apparatus of claim 12, wherein the one of a plurality of transmit precoders is indicated by using at least a transmit precoding matrix indicator (TPMI) and/or a sounding reference signal resource indicator (SRI) in a downlink control information (DCI) signalling.

14. The communication apparatus of claim 1, wherein the circuitry, in operation, associates the two or more uplink transmission spatial filters with at least one of sounding reference signal (SRS) resource sets for codebook-based transmission, wherein the at least one of SRS resource sets is associated with a channel state information reference signal (CSI-RS) resource.

15. The communication apparatus of claim 14, wherein the at least one of SRS resource sets is indicated by using at least a signal resource indicator (SRI) in a downlink control information (DCI) signalling.

16. A communication method, comprising:

receiving control information indicating two or more uplink transmission spatial filters for uplink transmissions; and

using the two or more uplink transmission spatial filters for a plurality of uplink transmission occasions based on the control information,

wherein

for codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a first transmit precoding matrix indicator (TPMI) and a first sounding reference signal resource indicator (SRI) in the control information, and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a second TPMI and a second SRI in the control information, and/or

for non-codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a first non-zero-power channel state information reference signal (NZP CSI-RS), and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a second NZP CSI-RS.

17. A base communication apparatus, comprising:

circuitry, which, in operation, generates control information indicating two or more uplink transmission spatial filters for uplink transmissions; and

a transmitter, which, in operation, transmits the control information,

wherein

for codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a first transmit precoding matrix indicator (TPMI) and a first sounding reference signal resource indicator (SRI) in the control information, and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a second TPMI and a second SRI in the control information, and/or

for non-codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a first non-zero-power channel state information reference signal (NZP CSI-RS), and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a second NZP CSI-RS.

18. A communication method, comprising:

generating control information indicating two or more uplink transmission spatial filters for uplink transmissions; and

transmitting the control information,

wherein

for codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a first transmit precoding matrix indicator (TPMI) and a first sounding reference signal resource indicator (SRI) in the control information, and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a second TPMI and a second SRI in the control information, and/or

for non-codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a first non-zero-power channel state information reference signal (NZP CSI-RS), and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a second NZP CSI-RS.

19. A integrated circuit configured to control a process of a communication apparatus, the process comprising:

receiving control information indicating two or more uplink transmission spatial filters for uplink transmissions; and

using the two or more uplink transmission spatial filters for a plurality of uplink transmission occasions based on the control information,

wherein

for codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a first transmit precoding matrix indicator (TPMI) and a first sounding reference signal resource indicator (SRI) in the control information, and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a second TPMI and a second SRI in the control information, and/or

for non-codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a first non-zero-power channel state information reference signal (NZP CSI-RS), and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a second NZP CSI-RS.

20. A integrated circuit configured to control a process of a base communication apparatus, the process comprising:

generating control information indicating two or more uplink transmission spatial filters for uplink transmissions; and

transmitting the control information,

wherein

for codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a first transmit precoding matrix indicator (TPMI) and a first sounding reference signal resource indicator (SRI) in the control information, and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with at least one of a second TPMI and a second SRI in the control information, and/or

for non-codebook-based transmission, a first uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a first non-zero-power channel state information reference signal (NZP CSI-RS), and a second uplink transmission spatial filter of the two or more uplink transmission spatial filters is associated with a second NZP CSI-RS.