ACOUSTIC WAVE FILTER INCLUDING TWO TYPES OF ACOUSTIC WAVE RESONATORS

CROSS REFERENCE TO PRIORITY APPLICATIONS

[0001] This application claims the benefit of priority of U.S. Provisional Patent Application No. 62/414,253, filed October 28, 2016 and titled "HYBRID SAW/BAW MULTIPLEXER;" U.S. Provisional Patent Application No. 62/426,104, filed November 23, 2016 and titled "HYBRID SURFACE ACOUSTIC WAVE AND BULK ACOUSTIC WAVE MULTIPLEXER;" and U.S. Provisional Patent Application No. 62/426,083, filed November 23, 2016 and titled "ACOUSTIC WAVE FILTER INCLUDING SURFACE ACOUSTIC WAVE RESONATORS AND BULK ACOUSTIC WAVE RESONATOR." The disclosures of each of these priority applications are hereby incorporated by reference in its entirety herein.

BACKGROUND

Technical Field

[0002] Embodiments of this disclosure relate to acoustic wave filters.

Summary

[0002A] According to one aspect, there is provided a filter assembly comprising: a first acoustic wave filter having a passband and being coupled to a common node; and a second acoustic wave filter coupled to the common node, the second acoustic wave filter including acoustic wave resonators of a first type and a series acoustic wave resonator of a second type coupled between the acoustic wave resonators of the first type and the common node, the series acoustic wave resonator of the second type having a higher quality factor in the passband of the first acoustic wave filter than the acoustic wave resonators of the first type, and the acoustic wave resonators of the first type of the second acoustic wave filter constitute at least 70% of resonators of the second acoustic wave filter.

[0002B] According to another aspect, there is provided a filter assembly comprising: a first acoustic wave filter having a passband and being coupled to a common node; and a second acoustic wave filter coupled to the common node, the second acoustic wave filter including acoustic wave resonators of a first type and a series acoustic wave resonator of a second type coupled between the acoustic wave resonators of the first type and the common node, the series

acoustic wave resonator of the second type having a higher quality factor in the passband of the first acoustic wave filter than the acoustic wave resonators of the first type, the acoustic wave resonators of the first type being non-temperature compensated surface acoustic wave resonators and the series acoustic wave resonator of the second type being a temperature compensated surface acoustic wave resonator. According to another aspect, there is provided filter assembly comprising: a first acoustic wave filter having a first passband and being coupled to a common node; a second acoustic wave filter coupled to the common node, the second acoustic wave filter including acoustic wave resonators of a first type and a series acoustic wave resonator of a second type coupled between the acoustic wave resonators of the first type and the common node; a third acoustic wave filter having a third passband and being coupled to the common node; and a fourth acoustic wave filter having a fourth passband and being coupled to the common node, the series acoustic wave resonator of the second type having a higher quality factor in the first, third, and fourth passbands than the acoustic wave resonators of the first type. According to another aspect, there is a provided filter assembly comprising: a first acoustic wave filter having a passband and being coupled to a common node; and a second acoustic wave filter coupled to the common node, the second acoustic wave filter including acoustic wave resonators of a first type and a series acoustic wave resonator of a second type coupled between the acoustic wave resonators of the first type and the common node, the series acoustic wave resonator of the second type having a higher quality factor in the passband of the first acoustic wave filter than the acoustic wave resonators of the first type, the filter assembly including a first die that includes the acoustic wave resonators of the first type and a second die that includes the series acoustic wave resonator of the second type. According to another aspect, there is provided multiplexer with acoustic wave filters, the multiplexer comprising: a first acoustic wave filter coupled to a common node, the first acoustic wave filter including acoustic wave resonators of a first type and a series acoustic wave resonator of a second type coupled between the acoustic wave resonators of the first type and the common node, the acoustic wave resonators of the first type being non-temperature compensated surface acoustic wave resonators and the series acoustic wave resonator of the second type being a temperature compensated surface acoustic wave resonator; and three other acoustic wave filters coupled to the common node and each having a respective pass band, the series acoustic wave resonator of the second type having a higher quality factor in each of the respective passbands of the three other acoustic wave filters than the acoustic wave resonators of the first type. According to another aspect, there is provided a method of processing a carrier aggregation signal, the method comprising: filtering the carrier aggregation signal with a first

acoustic wave filter that is coupled to an antenna port and has a first passband, the carrier aggregation signal including a first radio frequency carrier in the first passband and a second radio frequency carrier in a second passband; and filtering the carrier aggregation signal with a second acoustic wave filter that is coupled to the antenna port and has the second passband, the second acoustic wave filter including acoustic wave resonators of a first type and a series acoustic wave resonator of a second type coupled between the acoustic wave resonators of the first type and the antenna port, the series acoustic wave resonator of the second type having a lower loading loss than the acoustic wave resonators of the first type, and the acoustic wave resonators of the first type being on a different die than the series acoustic wave resonator of the second type. According to an aspect, there is provided a method of processing a carrier aggregation signal, the method comprising: filtering the carrier aggregation signal with a first acoustic wave filter that is coupled to an antenna port and has a first passband, the carrier aggregation signal including a first radio frequency carrier in the first passband and a second radio frequency carrier in a second passband; and filtering the carrier aggregation signal with a second acoustic wave filter that is coupled to the antenna port and has the second passband, the second acoustic wave filter including acoustic wave resonators of a first type and a series acoustic wave resonator of a second type coupled between the acoustic wave resonators of the first type and the antenna port, the series acoustic wave resonator of the second type having a lower loading loss than the acoustic wave resonators of the first type, the acoustic wave resonators of the first type being non-temperature compensated surface acoustic wave resonators and the series acoustic wave resonator of the second type being a temperature compensated surface acoustic wave resonator

Description of Related Technology

[0003] An acoustic wave filter can include a plurality of resonators arranged to filter a radio frequency signal. Example acoustic wave filters include surface acoustic wave (SAW) filters and bulk acoustic wave (BAW) filters. A film bulk acoustic resonator (FBAR) filter is an example of a BAW filter.

[0004] Acoustic wave filters can be implemented in radio frequency electronic systems. For instance, filters in a radio frequency front end of a mobile phone can include acoustic wave filters. Two acoustic wave filters can be arranged as a duplexer.