CASCADED RESONATOR WITH DIFFERENT REFLECTOR PITCH

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Patent Application Serial No. 62/940,075, titled "CASCADED RESONATOR WITH DIFFERENT REFLECTOR PITCH," filed November 25, 2019, incorporated herein by reference in its entirety for all purposes.

BACKGROUND

Technical Field

Embodiments of this disclosure relate to acoustic wave devices and electronic devices including same.

Description of Related Technology

Acoustic wave devices, for example, surface acoustic wave (SAW) and bulk acoustic wave (BAW) devices may be utilized as components of filters 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 or a diplexer. Multiple acoustic wave filters can be connected to work as a multiplexer, which may be used for carrier aggregation (CA) in LTE Advanced.

SUMMARY

In accordance with one aspect, there is provided an acoustic wave device. The acoustic wave device comprises a piezoelectric substrate, interdigital transducer electrodes having an electrode pitch λ_0, and first and second reflector gratings disposed on opposite respective sides of the interdigital transducer electrodes in a propagation direction of a main acoustic wave through the acoustic wave device, the first reflector grating having a different electrode pitch λ_1 than an electrode pitch λ_2 of the second reflector grating to suppress ripples in a conductance curve of the acoustic wave device.

In some ~~embodiments~~examples, one of λ_1 or λ_2 is equal to λ_0.

In some examples~~embodiments~~, each of λ_1 and λ_2 is different from λ_0. Each of λ_1 and λ_2 may be greater than λ_0. Each of λ_1 and λ_2 may be greater than λ_0 by between about 2% and about 5%.

In some examples~~embodiments~~, the acoustic wave device further comprises second interdigital transducer electrodes in series with the interdigital transducer electrodes, and third and fourth reflector gratings disposed on opposite respective sides of the second interdigital transducer electrodes in the propagation direction, the third reflector grating having a different electrode pitch λ_3 than an electrode pitch λ_4 of the fourth reflector grating.

In some examples~~embodiments~~, λ_1 is equal to one of λ_3 or λ_4.

In some examples~~embodiments~~, λ_2 is equal to one of λ_3 or λ_4.

In some examples~~embodiments~~, each of λ_1, λ_2, λ_3, and λ_4 is different.

In accordance with another aspect, there is provided an electronic device including at least two filters coupled to an antenna node, a first of the at least two filters being a ladder filter having a series resonator closest to the antenna node. The series resonator comprises a piezoelectric substrate, interdigital transducer electrodes having an electrode pitch λ_0, and first and second reflector gratings disposed on opposite respective sides of the interdigital transducer electrodes in a propagation direction of a main acoustic wave through the acoustic wave device, the first reflector grating having a different electrode pitch λ_1 than an electrode pitch λ_2 of the second reflector grating to suppress ripples in a conductance curve of the series resonator.

In some examples~~embodiments~~, each of λ_1 and λ_2 is greater than λ_0. Each of λ_1 and λ_2 may be greater than λ_0 by between about 2% and about 5%.

In some examples~~embodiments~~, the electronic device further comprises second interdigital transducer electrodes in series with the interdigital transducer electrodes, and third and fourth reflector gratings disposed on opposite respective sides of the second interdigital transducer electrodes in the propagation direction, the third reflector grating having a different electrode pitch λ_3 than an electrode pitch λ_4 of the fourth reflector grating.

In some examples~~embodiments~~, each of λ_1, λ_2, λ_3, and λ_4 is different.

In some examples~~embodiments~~, each of λ_3, and λ_4 is greater than an electrode pitch of the second interdigital transducer electrodes.

In some examples~~embodiments~~, one of λ_1 or λ_2 is equal to one of λ_3 or λ_4.

In accordance with another example~~aspect~~, there is provided a radio frequency filter including an acoustic wave resonator. The acoustic wave resonator comprises a piezoelectric substrate, interdigital transducer electrodes having an electrode pitch λ_0, and first and second reflector gratings disposed on opposite respective sides of the interdigital transducer electrodes in a propagation direction of a main acoustic wave through the acoustic wave device, the first reflector grating having a different electrode pitch λ_1 than an electrode pitch λ_2 of the second reflector grating to suppress ripples in a conductance curve of the acoustic wave resonator.

In some examples~~embodiments~~, each of λ_1 and λ_2 is greater than λ_0. Each of λ_1 and λ_2 may be greater than λ_0 by between about 2% and about 5%.

In accordance with another example~~aspect~~, there is provided an electronics module including a radio frequency filter including an acoustic wave resonator. The acoustic wave resonator comprises a piezoelectric substrate, interdigital transducer electrodes having an electrode pitch λ_0, and first and second reflector gratings disposed on opposite respective sides of the interdigital transducer electrodes in a propagation direction of a main acoustic wave through the acoustic wave device, the first reflector grating having a different electrode pitch λ_1 than an electrode pitch λ_2 of the second reflector grating to suppress ripples in a conductance curve of the acoustic wave resonator.

In accordance with another aspect, there is provided an electronic device. The electronics device comprises an electronics module including a radio frequency filter, the radio frequency filter including an acoustic wave resonator. The acoustic wave resonator includes a piezoelectric substrate, interdigital transducer electrodes having an electrode pitch λ_0, and first and second reflector gratings disposed on opposite respective sides of the interdigital transducer electrodes in a propagation direction of a main acoustic wave through the acoustic wave device, the first reflector grating having a different electrode pitch λ_1 than an electrode pitch λ_2 of the second reflector grating to suppress ripples in a conductance curve of the acoustic wave resonator.

In some examples~~embodiments~~, one of λ_1 or λ_2 is equal to λ_0.

In some examples~~embodiments~~, each of λ_1 and λ_2 is different from λ_0.

In some examples~~embodiments~~, each of λ_1 and λ_2 is greater than λ_0.