Coupling Device for Coupling Vibration Systems

The present invention relates to coupling devices for coupling vibration systems. In particular, the invention relates to micro-electro-mechanical components, such as inertial sensors, especially, rotation rate sensors, with multiple vibration systems that are coupled mechanically.

Modern micro-electro-mechanical systems (MEMS), such as inertial sensors, especially, rotation rate sensors, often include multiple vibration systems that vibrate in push-pull mode. This is sometimes used to make the forces and torque acting on the vibrating masses present in the vibration systems symmetrical in such a manner that the system is outwardly free of force and torque, at least in the time average.

It is known, for example, guiding two masses in opposite directions on one line. Various coupling mechanisms are known for such "dual mass sensors", which provide for vibration free of force and torque in the time average.

A problem arises, however, if multiple vibration systems are to be used which vibrate along the same direction, but are not arranged one after another in the direction of vibration, but in parallel. This is, particularly, the case for so-called "quad mass sensors", i.e., for rotation rate sensors that have four vibrating masses. These are paired to form two dual mass sensors, and each of the dual mass sensors can itself be coupled in the manner known. In addition to coupling the vibrating masses of the individual dual mass sensors in push-pull mode, the masses of the two dual mass sensors should also always be moved in push-pull mode, since this minimizes the total forces or torque. In addition, the movement of all masses should often be as one-dimensional as possible.

Prior art solutions to this problem couple the two dual mass sensors to one another by means of lever or rocker constructions. However, such constructions have the disadvantage that the ends of the levers do not describe straight-line trajectories, but circular trajectories due to the rigid design of the levers. The use of such levers thus pulls the coupled vibration systems out of their desired linear movement, especially for particularly preferred larger deflections of the vibration systems. Lever devices for the coupling of vibration systems thus systematically lead to an unwanted deflection of the vibrating masses from a purely linear movement and can also hinder the running of the masses in push-pull mode. These systematic errors lead to a deterioration of the measurement results, which can only be compensated for in a costly manner.

Therefore, embodiments of the present invention provide a coupling device for coupling at least two vibration systems, with which a movement of the vibration systems in the opposite direction can be reliably guided. Embodiments of the invention provide micro-electro-mechanical components, such as inertial/rotation rate sensors, which include such coupled vibration systems.

According to an aspect of the present invention, there is provided a micro-electro-mechanical component, preferably an inertial sensor, more preferably a rotation rate sensor for measuring a rotation of the rotation rate sensor, including: a coupling device for coupling a plurality of vibration systems, which are mounted above a substrate in such a manner that said systems can vibrate along a first direction and are offset with respect to one another in a second direction perpendicular to the first direction, wherein the coupling device has a bending beam spring which can bend in the first direction and is connected to the vibration systems, and connections of the bending beam spring to the vibration systems are arranged between two connection points of the bending beam spring to the substrate in such a manner that a deflection of the bending beam spring which is caused by movements of the vibration systems results in a vibration of the bending beam spring with vibration antinodes in the area of the connections of the bending beam spring to the vibration systems; and the plurality of vibration systems; wherein the number of vibration systems is N; a length of the bending beam spring between two connection points to the substrate is L; and the vibration system n (n=1, …,N) is connected to the bending beam spring at $(2n-1)\cdot L/2N$.

A coupling device for coupling a plurality of vibration systems, which are mounted above a substrate in such a manner that said systems can vibrate along a first direction and are offset with respect to one another in a second direction perpendicular to the first direction, can comprise a bending beam spring which can