High-Q Sapphire Resonator of Solid-State Gyroscope for Satellites and Inclinometry in Oil & Gas Industry

Description

A novel unique design & technology of a shell resonator for a solid-state Coriolis vibratory sensor **CRG-1** has been developed. This thin-walled resonator has been grown completely and without any mechanical machining from high-purity single-crystalline sapphire (together with its supporting flange). The proposed single-piece single-crystalline structure has a cost, reduced in order of value in respect to the well-known resonators, and it lets also develop a set of sensors with different diameters **below 20…25mm** to meet a range of customer's specs. Such tailored designs made from material, whose Q factor is in **10** times higher in respect to widely-used fused quartz (silica). Thus, we have a choice: to increase the grade of the gyro or to reach an inertial grade by simplified surface processing (*i.e.*, etching, magnetron filming, ion-beam and/or pure-electronic tunings).

Innovative Aspect and Main Advantages

CRG-1 has several similarities in respect to its analog HRG130, which is the best US sensor for NASA space missions ("Cassini") and for oil industry (*Northrop Grumman Corp.*, earlier – *Litton Guidance & Control Systems* and *Delco Electronics / GM*), and in respect to its a French analog (*Sagem Defense Securite*). The known sensors made from expensive high-purity quartz glass (fused quartz), which has a Q-factor smaller in order of value in respect to proposed man-made sapphire. These HRGs are fabricated by hard mechanical machining from a block of glass, and their production required highly-qualified technicians and expensive precise equipment.

The novel STM's labor-saving technology forwards this innovate competitive product into these specific markets. New generation of STM's resonators has a thicker flange (such kind of sapphire parts never were fabricated before by any other company) and an original elastic decoupling of sensing and fixture elements. This innovate development also based on huge STM's experience of several successful contracts on HRG-type sensors development & prototyping for the world-leaders.

Areas of Application

Satellites (stabilization and navigation for long-term space missions); Oil& gas industry (inclinometry of wells and drilling); another autonomous (stand-along) reference (strap-down) navigation systems.

Stage of Development

Two generations of sapphire resonators have been successfully fabricated by STM Co./ATSU; the sapphire samples have been also tested by an independent laboratory (M.V. Lomonosov's Moscow State University). It has interest for Fundamental Physics too (detectors of gravitational waves). The complete design of the device has been developed basing on positive STM experience of HRG development in past two decades. Thus, on technological and material level, – it is ready for market and do supported by really-operating facilities; on resonator level, – it is available for demonstration; on electromechanical block level, – it has been designed and will be available for demonstration; and on level of a complete instrument (and/or INS), – it can be developed in a variant tailored to customer's specs, basing on our previous HRG designs (including original elements of all control loops & electronics). All original designs and know-how developed by experts of STM Co./ATSU (a private spin-off of a Special DB). The designs and technique have fine engineering support thanks to the deep insights in math tools like detailed analytic modeling by perturbation methods, FEM simulation, close-loop analyses of these precise instruments, special DSP software, *etc*. Joint teamwork, patenting and co-investments would be discussed too.

Fig. 1. A single-piece sapphire preform for the gyroscopic resonator (before any processing)

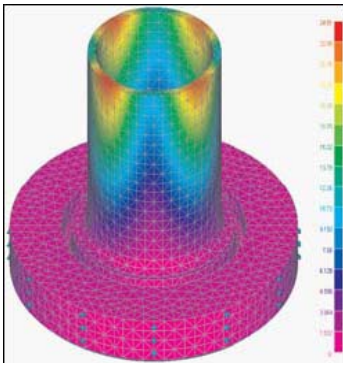

Fig. 2. FEM simulation of the operating modes of the sapphire resonator with a special elastic decoupling

Contact Details

Dr., Prof. Sergii Adolf. Sarapuloff,

Chief Designer & Head of lab., Member of ATS of Ukraine

International lab. on Micro Electromechanics Technologies founded by STM (Special Technologies & Machines) Co. / Ukraine's Academy of Technological Sciences (ATSU), and S.P. Timoshenko's Machine-Building faculty of Ukraine's National Technical University "Kyiv Polytechnic Institute" (KPI), and ISQ (Portugal).

Mail address: 13, Wishnyakivs'ka St., office 124, Zip Code 02140, Kyiv, UKRAINE.

Tel.: (+380-44) 577-1279, mobile (+380-50) 353-7760, fax (+380-44) 566-0103.

E-mail: stm@stm.kiev.ua