

9-Axis MEMS IMU

STMicroelectronics (LSM9DS0),

Bosch Sensortec (BMX055), InvenSense (MPU-9250)

Take the benefits of KnowMade and System Plus Consulting combined added value for highlighting potential risks of patent infringement.

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REPORT OUTLINE

- Technology and patent infringement risk analysis of 9-Axis MEMS IMU LSM9DS0 (STMicroelectronics), BMX055 (Bosch Sensortec) and MPU-9250 (InvenSense)
- September 2014
- PDF & Excel file
- 80+ slides
- €5,990

KEY FEATURES OF THE REPORT

- Deep insight on technology data and manufacturing processes
- Comparative studies of product features (similarities & differences)
- Key patents related to the target product features per company
- Cross analysis of potential patent infringement risks
- Excel database with all patents analyzed in the report

OBJECTIVES OF THE REPORT

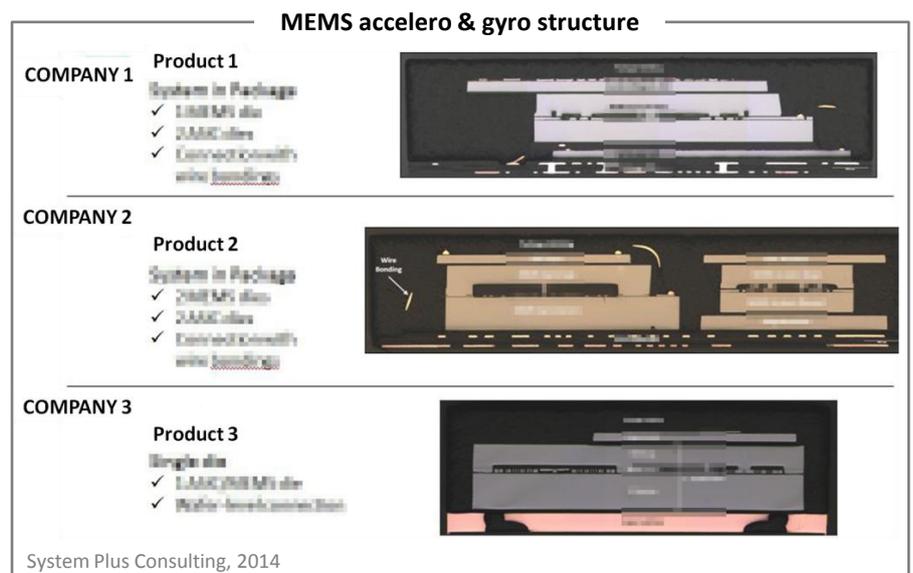
- Find the technical and manufacturing process similarities and differences of LSM9DS0, BMX055 and MPU-9250 9-axis IMU components.
- Identify key patents held by STMicroelectronics, Bosch Sensortec and InvenSense, and related to the target product features.
- Find the link between patented technological solutions and marketed products.
- Identify the potential infringing parties and help to find evidence of use.
- Identify potential risks of patent infringement and identify the patents which require a more in depth legal assessment.

RELATED REPORTS

- InvenSense MPU-9250 9-Axis IMU
- STMicroelectronics LSM9DS0 9-Axis MEMS IMU
- Bosch BMX055 9-Axis MEMS IMU
- MEMS Gyroscope Patent Investigation

Motion sensing combo sensor is a very hot topic, both in terms of market potential and competition among the players. The growth of the applications of 6 and 9 degrees of freedom (DoF) devices is both pushing the leaders (STMicroelectronics, Bosch Sensortec and InvenSense) and their challengers (AKM, Kionix, mCube, Freescale, Alps, Kionix...) to develop innovative technical and manufacturing solutions, and, in parallel of course, to have the right patents to protect their inventions. What are the similarities and the differences in term of technical and manufacturing choices at the devices level? What is the related patent situation?

For the first time, Knowmade (specialized in patent analysis) and System Plus Consulting (specialized in reverse engineering and reverse costing) are joining their unique added value in order to combined technology and manufacturing analysis with patent claims understanding to highlight the risks of patent infringement between **STMicroelectronics**, **Bosch Sensortec** and **InvenSense** in the field of **9 axis MEMS inertial measurement units (IMU)**. As the 9 axis IMUs are just starting to be adopted by the market, it is the right time now to understand what could happen between these 3 companies and how to differentiate patents and claims compared to the leaders.



2012 was seen by many as a turnkey year for consumer combo sensors (6 and 9 axis sensors). Since then, many developments have occurred and the market acceptance of combo solutions has been extremely quick. According to Yole Développement, the combo sensor market is estimated to be \$446M in 2013, growing to \$1.97B in 2018. This represents 21% of the global inertial consumer market in 2013, and will grow to an impressive 66% by 2018. In this playground, **STMicroelectronics (ST)**, **Bosch Sensortec (Bosch)** and **InvenSense** are the 3

market leaders in the inertial consumer sensors with more than 50% of market share.

In a patent infringement action, the potential sales volume plays a major role for assessing the damage award. Thereby, this study is naturally focused on the **newest 9-axis inertial MEMS components** supplied by these market leaders: **LSM9DS0** (STMicroelectronics), **BMX055** (Bosch Sensortec) and **MPU-9250** (InvenSense). Moreover, there exists a history of patent disputes between these 3 leading players.

This report provides an overview of technology data and manufacturing process of **LSM9DS0**, **BMX055** and **MPU-9250** 9-axis IMU components. A comparative study of the technology and manufacturing process of **9-axis IMU components** supplied by

STMicroelectronics, **Bosch Sensortec** and **InvenSense** has been performed in order to highlight the technical similarities and differences of the product features.

A LINK BETWEEN PRODUCT AND PATENT

A set of product features, mainly related to the accelero/gyro die, has been selected regarding their interest in terms of patent study:

- Al-Ge eutectic bonding process (Cap/Sensor, Sensor/IC).
- Accelero/Gyro single chip and the required multiple sealed cavities.
- 3-axis gyroscope single structure (sensing area).
- Hybrid MEMS with a vertically integrated electronics and a wafer-scale hermetic packaging.
- SiN as protective layer in sensor area (micromachined layers).

Key patents held by **STMicroelectronics**, **Bosch Sensortec** and **InvenSense** related to these technology features have been identified.

For each product feature, the links between the patented technologies and the target product have been established.

Technology and patent comparison

Product X

MEMS sensor and cap are sealed together with eutectic aluminum bonding process.

MEMS Cross-Section Overview

MEMS Sealing Cross-Section – SEM View MEMS Sensing Area – SEM View

PATENT

Relevant Patent Families: US 8,058,000 (2011), DE 10 2008 010 274 (2008), DE 10 2007 010 000 (2007)

Related Patent Families: DE 10 2007 010 000, DE 10 2007 010 000, DE 10 2007 010 000

US 8,058,000 (2011)

Method for bonding substrates

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Risk of patent infringement

Company 1

Product 1

Cross-section 1 plane

Cross-Section Overview – SEM View

highly likely infringement

Company 2

Intellectual Property (IP) rights

Granted patents: US 8,058,000, US 8,058,000, EP 2,500,000, EP 2,500,000, EP 2,500,000

Scope of the claims of US 8,058,000:

A method for manufacturing a micromechanical device including a substrate carrier having one or more cavities, the cavities being hermetically separated from each other, the cavities being formed by a different internal atmospheric pressure (10/11) (12/13).

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HIGHLIGHT PATENT INFRINGEMENT RISK

The potential infringing parties of the target product have been identified.

The contents of patents have been compared with actual technological solutions used in the marketed target products **LSM9DS0** (STMicroelectronics), **BMX055** (Bosch Sensortec) and **MPU-9250** (InvenSense), in order to highlight, for each 9-axis inertial MEMS component, the potential risks of patent infringement and related patents requiring more in-depth legal assessments. This report provides discussions on the potential risks of patent infringement by comparing relevant patent claim elements to the target product features.

We have identified several potential risks of patent infringements in some technology features from target products **LSM9DS0**, **BMX055** and **MPU-9250**. Key patents requiring more in-depth legal assessment have been identified.

AN USEFUL PATENT DATABASE

The report also includes an excel database with all patents analyzed in the report (60+ patent families composed of 200+ patents)

This database allows multi-criteria searches and includes :

- Patent publication number
- Hyperlinks to the original documents
- Priority date
- Title
- Abstract
- Applicants
- Legal status for each patent

Patent database

Number (Database)	Publication Number	Publication Date	Kind	Publication Stage History	PDF	Mosaic	Biblio	Register	BIB	Title	Assignee	Abstract	Claims	Inventors	Applicant
DE102012219511	2012-04-30	A1	[A1] Doc. laid open (First	Open	Open	Open	Open	Open	Open	Micromechanical	ROBERT BOSCH	Micromechan	(Claim	SCHUBEN	2013
CN103776427	2014-05-07	A	[A] Published application	Open	Open	Open	Open	Open	Open	PC weapon	ROBERT BOSCH	Micromechan	(Claims		2013
US20140116134	2014-05-01	A1	[A1] Application published	Open	Open	Open	Open	Open	Open	Micromechanical	ROBERT BOSCH	Micromechan	What is	CLASSEN	2013
DE102012219605	2014-04-30	A1	[A1] Doc. laid open (First	Open	Open	Open	Open	Open	Open	Micromechanical	ROBERT BOSCH	A	(Claim	GONSKA	2013
CN103787260	2014-05-14	A	[A] Published application	Open	Open	Open	Open	Open	Open	微机械结构件	ROBERT BOSCH	A	(Claims		2013
US20140117472	2014-05-01	A1	[A1] Application published	Open	Open	Open	Open	Open	Open	Micromechanical	ROBERT BOSCH	A	What is	GONSKA	2013
US20140110800	2014-04-24	A1	[A1] Application published	Open	Open	Open	Open	Open	Open	Method for	ROBERT BOSCH	A	What is	CLASSEN	2013
DE102012219465	2014-04-24	A1	[A1] Doc. laid open (First	Open	Open	Open	Open	Open	Open	Procedure for	ROBERT BOSCH	A	(Claim	CLASSEN	2013
CN103771333	2014-05-07	A	[A] Published application	Open	Open	Open	Open	Open	Open	For making cover	ROBERT BOSCH	A	(Claims		2013
US20130330448	2013-09-12	A1	[A1] Application published	Open	Open	Open	Open	Open	Open	Gyroscope self	INVENSENSE	A self-test	What is	ANAC OZAN	2013
WO2009130554	2009-10-29	A2	[A2] International	Open	Open	Open	Open	Open	Open	X-y axis dual-mass	INVENSENSE (US)	An angular	CLAIMS	SEEGER	2009
CN101938653	2011-01-05	A	[A] Published application	Open	Open	Open	Open	Open	Open	X-y axis dual-mass	INVENSENSE	An angular	CLAIMS	JOSEPH	2010
EP2238460	2010-10-13	A2	[A2] Application published	Open	Open	Open	Open	Open	Open	X-y axis dual-mass	INVENSENSE (US)	1-A sensor	CLAIMS	SEEGER	2009
JP2011525233	2011-09-15	A	[A] Published application	Open	Open	Open	Open	Open	Open	The electronic	INVENSENSE	Questel	What is	Seeger	2009
US2013034622	2013-12-19	A1	[A1] Application published	Open	Open	Open	Open	Open	Open	Micromechanical	ROBERT BOSCH	A	What is	GONSKA	2013
DE102012209973	2013-12-19	A1	[A1] Doc. laid open (First	Open	Open	Open	Open	Open	Open	Micromechanical	ROBERT BOSCH	A	(Claim	GONSKA	2013
DE102012208032	2013-11-14	A1	[A1] Doc. laid open (First	Open	Open	Open	Open	Open	Open	Hybrid integrated	ROBERT BOSCH	A hybrid	(Claim	CLASSEN	2013
CN103402034	2013-12-04	A	[A] Published application	Open	Open	Open	Open	Open	Open	Hybrid integrated	ROBERT BOSCH	The present	(Claims	CLASSEN	2013
TW201402449	2014-01-16	A	[A] Laid open application for	Open	Open	Open	Open	Open	Open	Hybrid	ROBERT BOSCH	A hybrid	What is	CLASSEN	2013
US20130307096	2013-11-21	A1	[A1] Application published	Open	Open	Open	Open	Open	Open	Hybrid integrated	ROBERT BOSCH	A hybrid	What is	CLASSEN	2013
US8564076	2013-10-22	B1	[B1] Granted patent as first	Open	Open	Open	Open	Open	Open	Internal electrical	INVENSENSE	A MEMS device	What is	HUANG	2013
US20140213007	2014-07-31	A1	[A1] Application published	Open	Open	Open	Open	Open	Open	Internal electrical	INVENSENSE (US)	A method of	(Claims	HUANG	2013
CN103964366	2014-08-06	A	[A] Published application	Open	Open	Open	Open	Open	Open	The internal	INVENSENSE	A MEMS device	(Claims		2014
EP2762441	2014-08-06	A2	[A2] Application published	Open	Open	Open	Open	Open	Open	Internal electrical	INVENSENSE (US)	A MEMS device	1. A MEMS	HUANG	2013
US20130277774	2013-10-24	A1	[A1] Application published	Open	Open	Open	Open	Open	Open	Method for	ROBERT BOSCH	A simple and	What is	FREY, ENIS	2013
DE102012206732	2013-10-24	A1	[A1] Doc. laid open (First	Open	Open	Open	Open	Open	Open	Procedure for	ROBERT BOSCH	A simple and	(Claim	FREY, ENIS	2013
CN103420235	2013-12-04	A	[A] Published application	Open	Open	Open	Open	Open	Open	Method for	ROBERT BOSCH	The present	(Claims	FREY, ENIS	2013
TW201348132	2013-12-01	A	[A] Laid open application for	Open	Open	Open	Open	Open	Open	Method for	ROBERT BOSCH	A simple and	(Claims	FREY, ENIS	2013

Knowmade, September 2014

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ABOUT SYSTEM PLUS CONSULTING (<http://www.systemplus.fr>)

Headquartered in Nantes, France, **System Plus Consulting** is specialized in technology and cost analysis of electronic components and systems in the fields of Integrated Circuits, Power Devices and Modules, MEMS & Sensors, LED, Image Sensors, Packaging including wafer level, Electronic Boards and Systems. The company offers custom reverse costing analyses, standard reverse costing reports and costing tools. These analyses are used by Purchasing Departments to measure their suppliers' cost structure, R&D Departments to confirm technological choices depending on their impact on costs, and Benchmarking/Marketing Departments to monitor the products on the market.

ORDER FORM

9-Axis MEMS IMU (STMicroelectronics, Bosch Sensortec, InvenSense) Technology and Patent Infringement Risk Analysis

September 2014

SHIP TO

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IBAN: FR76 1560 7000 6360 6214 5695 126
BIC/SWIFT: CCBPFRPPNCE

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“Products”: Reports are established in PowerPoint and delivered on a PDF format and the database may include Excel files.

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2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the Products and their conformity to the order. Any claim for apparent defects or for non-conformity shall be sent in writing to the Seller within 8 days of receipt of the Products. For this purpose, the Buyer agrees to produce sufficient evidence of such defects.

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BIC or SWIFT code: CCBPFRPPNCE

IBAN: : FR76 1560 7000 6360 6214 5695 126

To ensure the payments, the Seller reserves the right to request down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the «BCE» + 7 points, in accordance with article L. 441-6 of the French Commercial Code. Our publications (report, database, tool...) are delivered only after reception of the payment.

3.4 In the event of termination of the contract, or of misconduct, during the contract, the Seller will have the right to invoice at the stage in progress, and to take legal action for damages.

4. Liabilities

4.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for choosing the Products and for the use and interpretations he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces thereof.

4.2 The Seller shall only be liable for (i) direct and (ii) foreseeable pecuniary loss, caused by the Products or arising from a material breach of this agreement

4.3 In no event shall the Seller be liable for:

a) damages of any kind, including without limitation, incidental or consequential damages (including, but not limited to, damages for loss of profits, business interruption and loss of programs or information) arising out of the use of or inability to use the Seller's website or the Products, or any information provided on the website, or in the Products;

b) any claim attributable to errors, omissions or other inaccuracies in the Product or interpretations thereof.

4.4 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors.

4.5 All the Products that the Seller sells may, upon prior notice to the Buyer from time to time be modified by or substituted with similar Products meeting the needs of the Buyer. This modification shall not lead to the liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

4.6 In the case where, after inspection, it is acknowledged that the Products contain defects, the Seller undertakes to replace the defective products as far as the supplies allow and without indemnities or compensation of any kind for labor costs, delays, loss caused or any other reason. The replacement is guaranteed for a maximum of two months starting from the delivery date. Any replacement is excluded for any event as set out in article 5 below.

4.7 The deadlines that the Seller is asked to state for the mailing of the Products are given for information only and are not guaranteed. If such deadlines are not met, it shall not lead to any damages or cancellation of the orders, except for non-acceptable delays exceeding [4] months from the stated deadline, without information from the Seller. In such case only, the Buyer shall be entitled to ask for a reimbursement of its first down payment to the exclusion of any further damages.

4.8 The Seller does not make any warranties, express or implied, including, without limitation, those of saleability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes containing contaminating or destructive properties before making the Products available, the Seller cannot guarantee that any Product will be free from infection.

5. Force majeure

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor difficulties, equipment failure, late deliveries by suppliers or other difficulties which are beyond the control, and not the fault of the Seller.

6. Protection of the Seller's IPR

6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under French and international copyright law and conventions.

6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it to any other party other than employees of its company. The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:

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- Recordings and re-transmittals over any network (including any local area network);
- use in any timesharing, service bureau, bulletin board or similar arrangement or public display;
- Posting any Product to any other online service (including bulletin boards or the Internet);
- Licensing, leasing, selling, offering for sale or assigning the Product.

6.3 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.

6.4 The Buyer shall define within its company point of contact for the needs of the contract. This person will be the recipient of each new report in PDF format. This person shall also be responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company.

7. Termination

7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be borne by the Seller, following this decision.

7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

8. Miscellaneous

All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer.

Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party.

The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

9. Governing law and jurisdiction

9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract (orders) entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Grasse, which shall have exclusive jurisdiction upon such issues.

9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.