Session: Nanodevices and Nanofabrication MEMS/ Sensor Technology

Sub-1mG Inertial Sensors by Multi-layer Metal Technology

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Abstract

MEMS (Microelectromechanical systems) technology has enabled us to miniaturize inertial sensors, such as accelerometers and gyroscopes. In recent years, MEMS inertial sensors have been widely used for various application in our daily life. Currently, one of the major research topics on MEMS accelerometers would be accurate sensing of sub-1mG (G: gravitational acceleration) acceleration. Such a highly-sensitive accelerometer could be useful for human-activities monitoring, infrastructure monitoring, mobile-vehicle control and space applications. The minimum detectable acceleration of MEMS accelerometers is basically determined by the thermo-mechanical noise of proof mass. The thermo-mechanical noise is dominated by Brownian noise (B_N), and B_N is inversely proportional to proof mass. So far, silicon is used as the material of proof mass in conventional MEMS accelerometers. The minimum B_N level of typical silicon proof mass in MEMS accelerometers is in the range from 100 to 1000 $\mu G/Hz^{1/2}$.

In this talk, we will present a new approach to reduce the B_N on MEMS accelerometers. We have proposed to use electroplated gold as a material of the proof mass. The density of gold is about ten times higher than that of silicon, and therefore the B_N of gold proof mass can be an order of magnitude smaller than that of silicon proof mass. Furthermore, the MEMS accelerometer can be made by a post-CMOS (complementary metal-oxide semiconductor) process. With the above approaches, the B_N of the developed MEMS capacitive sensor with a gold proof mass was experimentally evaluated to be less than 1 $\mu G/Hz^{1/2}$, which has the potential of sub-1mG sensing.

CV and a short publication list

Daisuke Yamane received the B.S., M.S., and Ph.D. degrees in electrical and electronic engineering from The University of Tokyo, Tokyo, Japan, in 2006, 2008, and 2011, respectively. From 2010 to 2012, he was a Research Fellow of the Japan Society for the Promotion of Science hosted within the Research Center for Advanced Science and Technology, The University of Tokyo. From 2011 to 2012, he was a Visiting Scholar at the University of California, Los Angeles, CA, USA. From 2012 to 2015, he was an Assistant Professor with Precision and Intelligence Laboratory, Tokyo Institute of Technology, Kanagawa, Japan. Since 2016, he has been an Assistant Professor with Laboratory for Future Interdisciplinary Research of Science and Technology, Tokyo Institute of Technology, Kanagawa, Japan. His research interests include radio-frequency (RF) microelectromechanical systems (MEMS), MEMS inertial sensors, and (complementary metal-oxide semiconductor) CMOS-MEMS technology.

Recent 5 publications: Total 26 Journal Papers and 72 International Conference Proceedings (11 invited talks)
1. D. Yamane et al., "Evaluation and Modeling of Adhesion Layer in Shock-Protection Structure for MEMS Accelerometer," Microelectron. Reliab., vol. 66, pp. 78-84, 2016.
2. D. Yamane et al., "A 1-mG MEMS Sensor," ECS Transactions, vol. 72, issue 3, pp. 7-14, 2016.
3. D. Yamane et al., "A Dual-Axis MEMS Capacitive Inertial Sensor with High-Density Proof Mass," Microsyst. Technol., vol. 22, pp. 459-464, 2016.
4. D. Yamane et al., "A 0.1G-to-20G Integrated MEMS Inertial Sensor," Jpn. J. Appl. Phys., vol. 54, no. 8, pp. 087202.1-087202.4, 2015.
5. D. Yamane et al., "Design of sub-1g microelectromechanical systems accelerometers," Appl. Phys. Lett., Vol. 104, Issue 7, 074102, 2014.