Micromachined piezoelectric harvester drives fully autonomous wireless sensor

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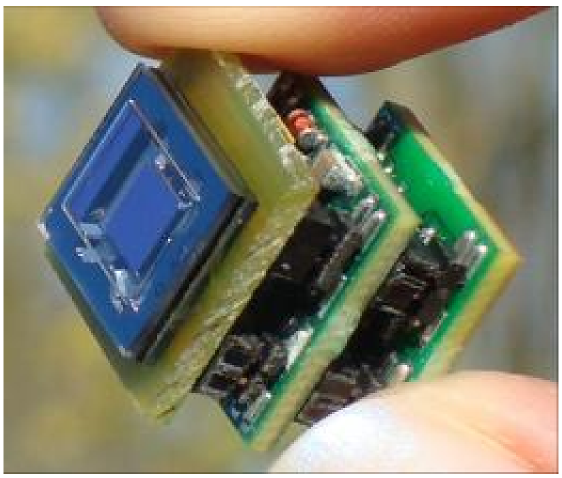

Fully autonomous wireless temperature sensor powered by a vibrational energy harvester

For the first time, a piezoelectric harvesting device fabricated by MEMS technology generates a record of 85µW electrical power from vibrations. A wafer level packaging method was developed for robustness. The packaged MEMS-based harvester is used to power a wireless sensor node. Within the Holst Centre program on Micropower Generation and Storage, imec researchers developed a temperature sensor that can wirelessly transmit data in a fully autonomous way.

Micromachined vibrational energy harvesters operating in the frequency domain between 150 and 1000Hz are ideal devices to convert vibrations from machines, engines and other industrial appliances into electricity. Thanks to their smaller dimensions, the micromachined devices are the prefered candidates for powering miniaturized autonomous sensor nodes.

Record and novel material

By using cost-effective, CMOS compatible MEMS processes on 6' silicon wafers, imec developed piezoelectric energy harvesters capable of generating up to 85µW of power.

The harvester consists of a Si mass that is suspended on a beam with Aluminum Nitride (AlN) as piezoelectric material. By changing the dimensions of the beam and mass, the resonance frequency of the harvester can be designed for any value in the 150-1200Hz domain.

Not only the record power output, but also the use of AlN as piezoelectric layer, is a notable achievement. AlN has several advantages in terms of materials parameters and ease of processing compared to the commonly used PZT (Lead zirconate titanate). Just to name two: AlN can be deposited up to three times faster while composition control is not an issue, thanks to the stoichiometric nature of the material.

Vacuum package

Final achievement in the research is the development of a wafer-scale process to protect the piezoelectric devices by a package. It was shown that the power output significantly increases by the use of the vacuum package compared to packaging in atmospheric pressure. In a three step process, glass covers are coated with an adhesive, vacuum bonded on top and bottom of the processed wafer and diced.

Fully autonomous

The piezoelectric harvester was connected to a wireless temperature sensor, built op from of-the-shelf components. After power optimization, the consumption of the sensor was reduced from 1.5mW to ±10μW, which is an improvement by three orders of magnitude. When subjected to vibrations at 353Hz at 0.64g (indicating a realistic amplitude of the vibrations), the system generated sufficient power to measure the environmental temperature and transmit it to a base station with an interval of fifteen seconds. The result proves the feasibility of building fully autonomous harvesters for industrial applications.

Once fully mature, the technology can be used to power sensors in industrial applications such as tire-pressure monitoring and predictive maintenance of moving or rotating machine parts. Imec and Holst Centre do not go to market themselves, but perform the research together with industrial players interested in commercializing the technology.

The result was obtained within the Micropower Program at Holst Centre, an open-innovation initiative by IMEC and TNO (The Netherlands). All details of the research were presented during the 2009 IEEE International Electron Devices Meeting (IEDM) in Baltimore (December 7-9).

Provided by IMEC

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