Green Sensor Network System Technology Development Project

Development Plans

	FY 2011	FY 2012	FY 2013	FY 2014
	(1) Electric current/magnetic field sensors, (2) dust sensors, (3) CO_2 sensors, (4) VOC sensors, (5) infrared array sensors			
	Develop small, low-power MEMS sensors			
R&D Project 1 Development of green MEMS sensors	Confirm component principles, developelement prototypes, conduct basic tests, etc.	Develop micro-size sensor prototypes, establish design and production technologies, etc.	●MEMS sensors no larger than 2x5cm ●Average power consumption no greater than 100 μW	
	Develop green sensor nodes with stand-alone power system			
R&D Project 2 Development of green sensor nodes with stand-alone power system	Explore the most efficient power-generating materials and devices, and design and prototype power device and component circuit blocks	Perform basic development of efficient powergeneration /storage module, verify power supply system, validate sensor node operations, and verify module's low-power effect	●Develop 3-mm-square main node chip ●Develop integrated device combining power generation and storage that is capable of supplying power at an average output greater than 150 μW ●Develop green sensor node no larger than 2x5cm ●Develop receiver capable of connecting to 1,000 or more nodes simultaneously and having a receiving sensitivity greater than -130 dBm	
		Incorporate results of validation tests in sensor prototypes		
			Introduce innovative sensors for validation as they are produced	
	Formulate, verify, validate			
R&D Project 3 Construction of a green sensor network system and demonstration tests	Package a prototype sensor, construct a pre-monitoring system, and conceptually design a data analysis system	Conduct monitoring with prototype sensors and identify detailed specifications of green sensor network	Construct a network system incorporating green MEMS sensors, green sensor nodes, and high-sensitivity receivers, and verify the functions of a network system required for practical use, through demonstration tests in various environments, including stores, offices, and manufacturing sites	

Commercialize green sensor network system

Research Implementing Structure

Technical research for this project is conducted at two research centers, the Tsukuba Research Center and the Ookayama Research Center of the Green Sensor Network System Laboratory , as well as research centers established at participating companies.

NEDO

(Joint Research Project : FY2011–2014)

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NMEMS Technology Research Organization

Green Sensor Network System Laboratory
(Director of research: Dr. Ryutaro Maeda)

- **Tsukuba Research Center,** AIST Tsukuba East
  Recommissioning: the University of Tokyo and Shinshu University
- **Ookayama Research Center,** Tokyo Institute of Technology
  Recommissioning: Shinshu University
- **Corporate Research Centers**

Members of NMEMS Technology Research Organization
ULVAC,Ink.
NTT DATA CORPORATION
OMRON Corporation
Olympus Corporation
Suminoe Textile Co.,Ltd.
Seiko Instruments Inc.
Seven-Eleven Japan Co.,Ltd.
DAIKIN INDUSTRIES,LTD
Dai Nippon Printing Co.,Ltd
Takasago Thermal Engineering Co., Ltd.
DENSO CORPORATION
The Tokyo Electric Power Company,Incorporated
Toko Electronic Corporation
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Yokogawa Electric Corporation
ROHM Co.,Ltd.
National Institute of Advanced Industrial Science and Technology(AIST)
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Green Sensor Network System with Low-Cost, Layout-Free, and Maintenance-Free MEMS Sensors

NEDO Joint Research Project The Sensor System Development Project to Solve Social Problems (Green Sensor Network System Technology Development Project) **(FY2011-2014)**

Purpose

To develop revolutionary sensors that incorporate wireless communication, stand-alone power system, and ultra-low power consumption functions (thereby resolving three issues common to all sensor devices used in sensor networks) and to conduct energy-savings validations, making it possible to perform environmental measurements and to acquire measurements of energy consumption and the like (visualization) and to control the quantity of energy consumption(optimization) through the introduction of a sensor network.

R&D Project 1 Development of Green MEMS Sensors

Final Targets

- MEMS Sensors no larger than 2x5cm
- Power consumption no greater than 100 μW for all sensors
- Electric current and magnetic field (electrical energy), dust, gas (CO_2/VOC) concentration (air conditioning and ventilation), infrared array (human presence and motion and ambient temperature sensing)

R&D Project 2 Development of Green Sensor nodes with Stand-Alone Power system

Final Targets

To create prototypes of the following green sensor nodes to be installed in various electronic equipment, air conditioning units, manufacturing equipment, panelboards, and other devices without requiring any reconfiguring or additional work.

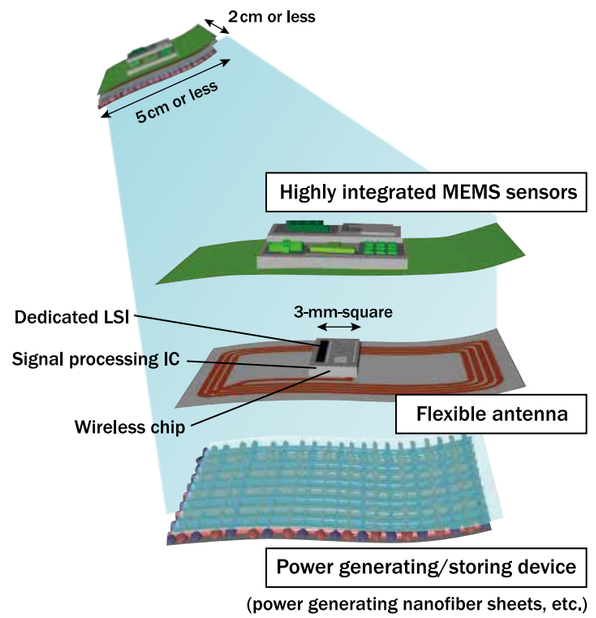
- Develop a 3-mm-square main node chip provided with a function for collecting and processing signals from MEMS sensors and a function for transmitting measurement data wirelessly
- Develop an integrated device combining power generation and storage that is capable of supplying power at an average output greater than 150 μW, which is required by green sensor nodes under indoor lighting conditions, temperatures between 5 and 35°C, and other ambient conditions set in demonstration tests for R&D Project 3
- Develop a green sensor node that includes the MEMS sensor unit, the main node chip, and the integrated power generation/storage device at a size no greater than 2x5cm
- Develop a receiver that can be connected to 1,000 or more nodes simultaneously and can simultaneously receive signals in at least two frequency bands, 300 MHz and 900 MHz, at a receiving sensitivity greater than -130 dBm

R&D Project 3 Construction of a Green Sensor Network System and Demonstration Tests

Final Targets

Construct a network system incorporating green MEMS sensors, green sensor nodes, and high-sensitivity receivers, and thereby develop a system suitable for the environments of stores, offices, and manufacturing sites

Green Sensor node



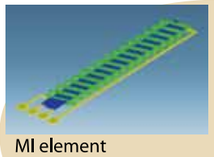
NMEMS Technology Research Organization
URL: http://www.nmems.or.jp

R&D Project

1 Development of Green MEMS Sensors

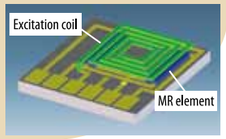
Electric Current and Magnetic Field Sensors

Achieve an ultra-small, ultra-sensitive sensor through a technique for MEMS and magnetic materials .tic material and produce a flexible coil electric current sensor with increased flexibility and a lower cost by microfabricating microcoils. By equipping a sensor network system with electric current and magnetic field sensors to take detailed measurements, it is possible to visualize the actual amount and effects of power consumption.



MI element

Flexible coil electric current sensor

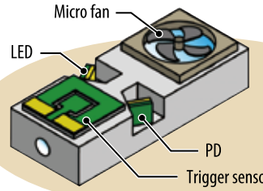


MR element

Electric current/ magnetic field sensor

Dust Sensors

Acquire environmental data such as dust levels in a precision parts factory and the like using dust sensors with an added trigger mechanism. Incorporation of the trigger mechanism makes it possible to reduce power consumption.

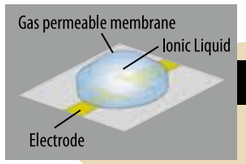


Dust sensor

Gas Sensors

① CO_2 Sensors

Achieve a CO_2 sensor based on MEMS technology despite the perceived difficulty of making CO_2 sensors smaller and more power-efficient. By measuring CO_2 concentrations, the effect of optimizing the control of supplied airflow in the air conditioning on energy reduction can be determined.

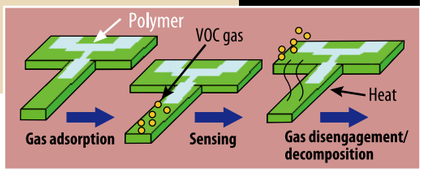


CO_2 sensor

② VOC Sensors

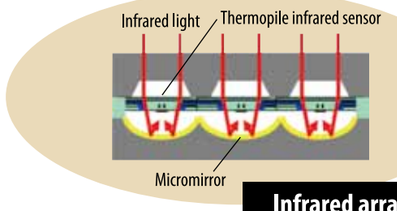
By modularizing an ultra-small, polymer-based, low-power oscillating VOC sensor, we consider the possibilities of implementing a handy TVOC sensor for indoor use in offices and stores and achieve positive energy-saving effects through optimal air conditioning control.

VOC sensor



Infrared Array Sensors

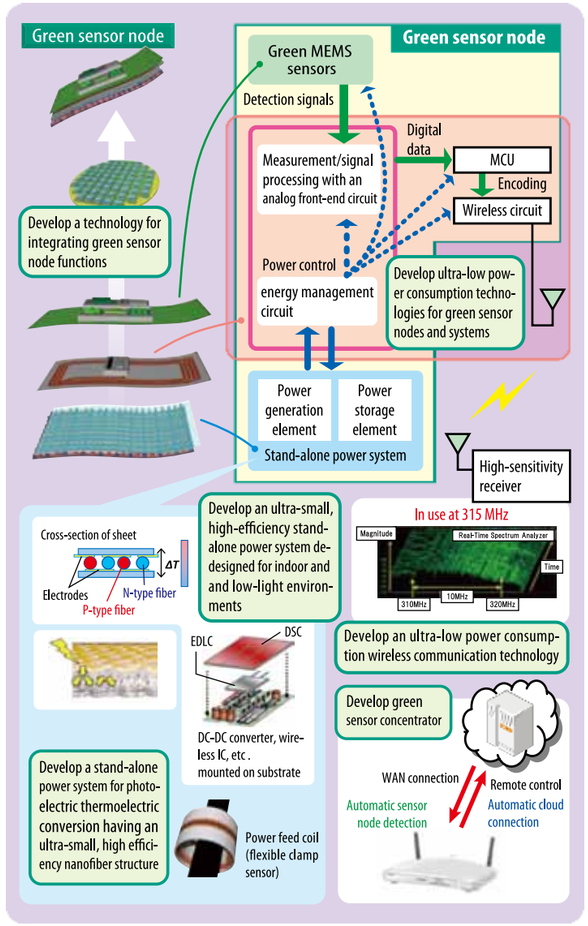
Achieve a small, highly-sensitive, and quick response infrared array sensor by using MEMS technology. Implement simultaneous measurements of human numbers, movement, and positions and ambient temperature in offices and factories in order to improve energy efficiency through optimal control of air conditioning, lighting, and the like.



Infrared array sensor

R&D Project

2 Development of Green Sensor nodes with Stand-Alone Power System



Development of a Stand-Alone Power System for Photoelectric-Thermoelectric Conversion Having an Ultra-Small, High-Efficiency Nanofiber Structure

Develop high- efficiency energy conversion elements having a 3D textile structure of nanofibrous organic semiconductor, and a hybrid stand-alone power system using multiple types of ambient energy (light and heat)

Develop an Ultra-Small, High-Efficiency Stand-Alone Power System Designed for Indoor and Low-Light Environments

- Develop a backward current suppression DSC (dye-sensitized solar cell) for indoor use, and a low leakage current EDLC (electric double layer capacitor)
- Develop a fabrication process of magnetic thin films for a flexible clamp sensor (electric current sensor) that is capable of wireless charging by an electromagnetic coil, and a monolithic molding process of flexible microcoils

Development of an Ultra-Low Power Consumption Technology for Green Sensor nodes and Systems, a Technology for the Integration of Green Sensor node Functions, and a Technology for Ultra-Low Power Consumption Wireless Communications

- Develop a fast time-division multiplexing analog circuit for reducing energy consumption in measurements and signal processing by at least 50% and a node energy management circuit for monitoring power generation and consumption at all nodes and for performing power control at the startup time to less than 1/100th that of conventional technology
- Develop integration and packaging technologies through low-temperature bonding of TSV interposers suitable for wafers up to 300 mm and heterogeneous chips, and a supercritical fluid deposition technology for depositing metal in trench capacitors and TSVs
- Develop a wireless communication technology that allows multiple simultaneous accesses while reducing radiated power at the nodes to less than 1/10th that of conventional nodes by reducing the data length and improving sensitivity ten times over conventional devices

Development of Green Sensor Concentrators (GCON)

Develop a compact low-power prototype GCON device for collecting and compressing sensor data without a computer and design and verify a system capable of automatically connecting GCON devices to green sensor nodes and the cloud, automatically constructing a mesh network linking GCONs, and adding compatible sensors by remotely modifying the firmware

R&D Project

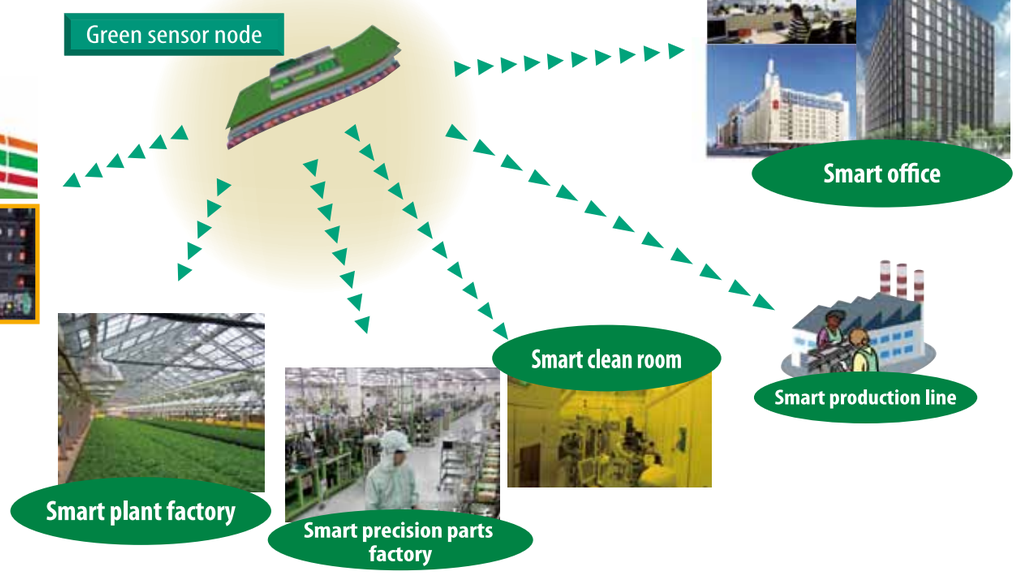
3 Construction of a Green Sensor Network System and Demonstration Tests

Smart Convenience Store

Develop and install a store with sensor node prototypes, monitor the nodes for more than one year, and identify detailed specifications of the nodes and the system. Develop practical wireless sensor nodes based on the specifications and construct a green sensor network system that, when combined with a profiling system, can achieve energy savings of more than 10%.

Smart Office

Implement comprehensive monitoring of an office space that included, in addition to the evaluation of basic data, monitoring of gas concentrations and human-related information. Study new visualizations and optimizations, such as the visualization of energy consumption per person, and verifiy this data from multiple angles.



Smart Factory

(1) Smart precision parts factory

Acquire dust levels, temperature, and other ambient data in a precision parts factory using nodes with built-in dust sensors equipped with a trigger mechanism

(2) Smart plant factory

Employ an energy-harvesting stand-alone power system in a plant factory and chemical products factory to drive CO_2 sensors and various existing sensors for detecting illumination, temperature, humidity, and the like and verify the relationship between the environments and productivity

(3) Smart clean room

Operate a wireless sensor network designed specifically for clean room applications and monitor ambient conditions

(4) Smart production line

Construct a wireless network system equipped with electric current sensors and verify the energy-saving effects for each production line