SERVICES AND CONTACT

Research and Development Services
The Fraunhofer Project Center »NEMS/MEMS Devices and Manufacturing Technologies at Tohoku University« offers research and development services in the following fields:
- Smart systems
- MEMS/NEMS from design to prototype
  - Silicon-based
  - New materials based (e.g. amorphous metal, gallium, polymers, etc.)
- Technologies for MEMS/NEMS, smart systems and system integration
  - Silicon-based technologies for MEMS/NEMS
  - Polymer-based technologies
  - System integration (wafer bonding, 3D integration and packaging)
- Basic technologies (e.g. lithography, layer deposition, etching, etc.)
- Test, modeling and analysis for design, characterization and reliability

Fraunhofer Project Center
NEMS/MEMS Devices and Manufacturing Technologies at Tohoku University

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Cover page Interface of solid liquid interdiffusion bond based on gallium.
1 Cu micro coil for integration in acoustic MEMS.
2 Low-temperature waferbonding for sensor devices.
(cooperation partner EPC TDK)
Aim of the Fraunhofer Project Center
The Fraunhofer Project Center is a platform for common research and development activities of Tohoku University and Fraunhofer Institute for Electronic Nano Systems ENAS. The Fraunhofer Project Center is run to the benefit of both partners as a vehicle for:
- R&D cooperation in advanced manufacturing technologies as well as development and applications of new materials for microelectronic systems with a focus on NEMS/MEMS and micro/nano manufacturing technologies,
- Facilitating and expediting the commercialization of research and the transfer and adoption of new materials manufacturing technology by industry, particularly manufacturers of microsystems and semiconductor devices,
- Exploitation of new markets in the field of micro/nano systems manufacturing sectors,
- Introducing methods and standards of Fraunhofer-Gesellschaft for industrial collaboration to the research community in Japan and vice versa,
- Training the next generation of researchers, engineers and technicians through joint research programs.

Cooperation Tohoku University and Fraunhofer ENAS
Tohoku ENAS and the Tohoku University have been cooperating in the field of new materials for microelectronic systems for many years. Tohoku University did set-up a strategic research initiative by establishing a joint research and development unit at Tohoku University. The Fraunhofer Project Center “NEMS/MEMS Devices and Manufacturing Technologies at Tohoku University” has started April 1st, 2012. After a successful first term of five years, both partner organizations decided to further extend its operation.

Tohoku University
Tohoku University was founded in 1907 as the third Imperial University of Japan; from its start, it displayed to the world an ambition to an “Open Door” policy. This policy has contributed to producing a large number of notable research achievements and outstanding scholars, including Nobel Prizes in 2002, 2007 and 2011. The Tohoku University is a leading research-intensive university and has a worldwide recognized strength in materials engineering and science. The university is comprised of 10 undergraduate faculties, 16 graduate schools, 3 professional graduate schools, 6 research institutes, 18 research centers and a university hospital. As of May 2018, there were about 6400 faculty and staff members as well as approximately 16,500 students.

Fraunhofer-Gesellschaft
Fraunhofer-Gesellschaft is Europe’s leading research institution with more than 25,000 employees and 72 institutes and independent research units. The Fraunhofer Institute for Electronic Nano Systems ENAS has developed world-class expertise in smart systems integration by using micro and nanotechnologies. Individual solutions are sought in direct contact with industrial customers. The key objective of Fraunhofer-Gesellschaft is to transform scientific expertise into applications for practical use. Thus, Fraunhofer makes a significant contribution to technological transfer between universities and industry.

RESEARCH TOPICS
FPC is targeting on research and development in the field of smart systems integration by using micro and nano technologies and implementing newest material knowledge. With its orientation towards smart systems integration, the FPC addresses the challenges of a digitized world, the internet of things as well as industry 4.0 and hence, global challenges such as an aging population and society 5.0 in Japan and Germany.

Focused research topics are:
- MEMS sensors and actuators (e. g. acoustic, optical, and inertial MEMS)
- Bonding technologies for chip- and wafer level packaging (e. g. permanent and temporary as well as low temperature wafer bonding technologies)
- Bonding by using nano scale effects and innovative materials
- Mechanical and structural properties of micro structures made from sputtered amorphous metal
- Deposition and integration of magnetic materials for MEMS applications
- Thin film encapsulation technologies

Acoustic (audio) MEMS devices
The use of miniaturized-acoustic devices has significantly increased over the past few years in response to the flourishing market of mobile electronic devices with built-in audio systems. Those devices are loudspeakers and microphones. The FPC is developing MEMS loudspeakers with low power consumption, large bandwidth, high toughness towards humidity and dust. Electromagnetic interaction is suitable for actuation with high force. Usually this requires the additional integration of external magnets and electromagnetic functional elements, such as external coils. For the acoustic MEMS speaker, the integration of hard magnetic materials, like Nd-Fe-B, into the MEMS fabrication process are examined. Furthermore, copper micro coils made by using electro plating are integrated to replace the external coil used for generating the electromagnetic field for actuation. This provides the possibility for very small device sizes. For another method, electrostatic actuation, research to reduce voltage and increase audio quality by novel design is conducted. As for MEMS microphones, by integration of high strength amorphous metals as diaphragm materials, devices with very large mechanical compliance, yet high toughness are researched. Furthermore, new transducer principles with high sensitivity and low noise beyond capacitive detection are under investigation.

Low-temperature solid-liquid interdiffusion bonding for micro devices
Development of the alloying of gallium / gold and gallium / copper near the melting point of gallium for the application of metal interdiffusion bonding of semiconductors near room temperature is being carried out. Therefore an electrodeposition process to uniformly coat semiconductor surfaces with gallium has been developed. The alloying process itself and its most important parameters are being investigated and optimized. The process is characterized by the intermetallic composition of the resulting alloy and extensive research of the shear strength, electrical conductivity and hermeticity. All these characteristics have been meanwhile improved up to a similar level like other well-known metal based semiconductor bonding processes, like thermo-compression bonding. Furthermore, micro structural analysis of the interfaces made at different temperatures is being carried out to better understand the mechanism of the bonding and the mechanism of the temperature dependence. The result of the research is a unique thin film liquid metal based bonding process for MEMS near room temperature.

OVERVIEW