

IcAUMS：アジア磁気学会連合国際会議

日程：2025年4月21日～24日

場所：沖縄コンベンションセンター(沖縄県宜野湾市)

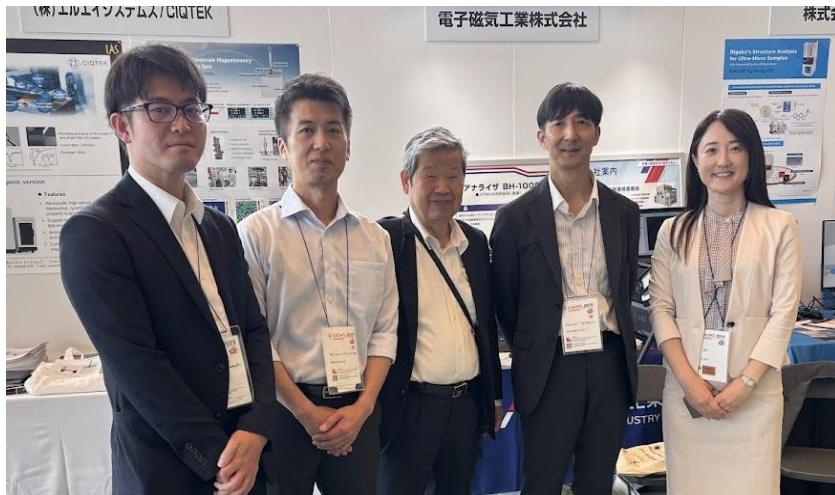
IcAUMS 2025

ドキュメンタリー

総合委員長:竹村泰司(横浜国立大学 教授)

会議委員長:柳原英人(筑波大学 教授)

この度マグネデザインは、アジア磁気学会連合国際会議にて研究発表しました。日本磁気学会 会長の竹村泰司様、元会長の杉本諭様、高梨弘毅様、Invited speakerのArcady Zhukov教授ほか沢山の学会幹部の方と懇談させて頂きました。これを機会に瓦解活動に積極的に参加していく所存です。



日本磁気学会会長 竹村泰司教授(横浜国立大学)



バスク大学

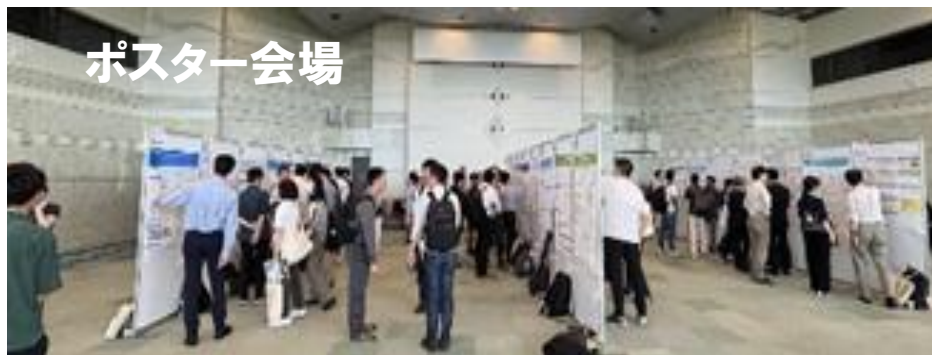
Prof. Arcady Zhukov

Prof. Valentina Zhukova



東北大学
藪上信教授

ポスター2件発表。ポスターセッションで、新たなネットワークも広がりました。



ポスター会場



東北大学
青木英恵講師

名古屋大学 加藤剛志教授

日本大学 塚本新教授

慶応義塾大学 学生

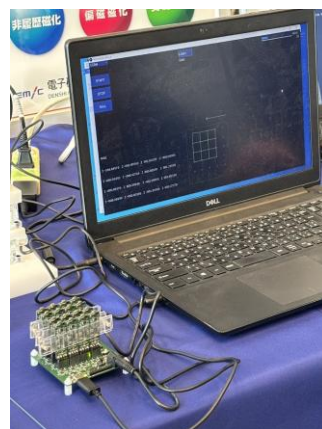
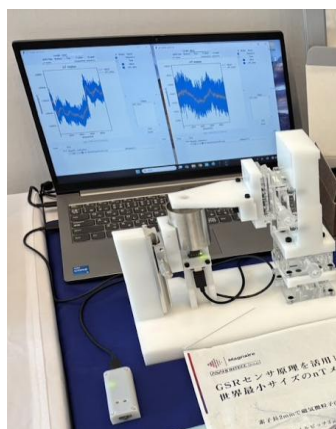


電子磁気工業株式会社と共同出展させて頂きました



nTメータおよび
微粒子検出装置

16chグリッドセンサ



こ来場者は、小型・高感度性能に大変驚いていました。

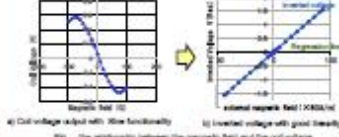
Development of nT meter applied by GSR sensor

M. Hikishima, S. Honkura, Y. Honkura
Magnedesign corporation, Aichi, JAPAN

GSR characteristics

Magnetic field and Coil voltage

- The size functionality between the magnetic field and the coil voltage.
- The inverted voltage shows that the noise linearity is only 0.5% FS.



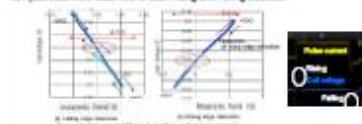
Frequency response

- The sensitivity increases with the increase of frequency following saturation up to over 30kHz.
- The magnetic sensitivity increases with the number of coil turns.



Hysteresis

- No hysteresis was observed for both Rising and Falling detection.



nT meter

Specification of nT meter

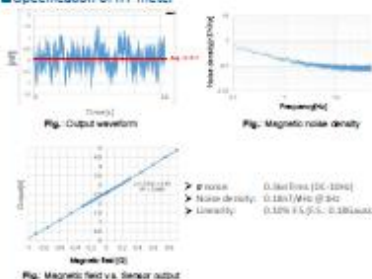


Fig. 1. Specification of nT meter

Item	Condition	Typ.	Standard
Range		nT/75pT	2nT-75pT
Linearity	F.S. ±1.75pT	0.3% F.S.	0.2% F.S.
Band		DC-450Hz	
Sensitivity	25mV/1T	25±0.5mV/1T	
α noise	DC-10Hz	0.43nT	±0.7nT
	DC-450Hz	1.23nT	±0.2nT
Power supply		5V (±0.05V)	
Power		0.56W	0.56±0.03W

Abstract

Coil-type high-sensitivity magnetic sensors have progressed from FG sensors and MI sensors to the development of GSR sensors, the magnetic core material was changed from permalloy to amorphous magnetic wire, and the excitation pulse frequency was increased to 100, MHz, and GHz to reduce coil size and high sensitivity. In the evolution frequency of the GHz band, the magnetic wall movement is suppressed, and the ultrasonic rotation of spins in the surface magnetic domain is induced to achieve high sensitivity, good linearity, and no hysteresis.

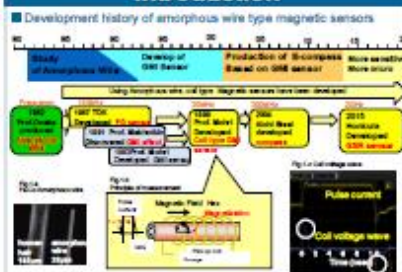
The GSR element, length 2 mm, 10μm diameter, and the number of coil turns 500. As a result, we succeeded in developing an nT level detection.

In recent years, research on nT sensors for detecting small magnetic fields below the nT level, such as detection of small magnetic fields emitted from organisms, detection of magnetic nanoparticles in Li-ion batteries and food products, and detection of cancer cells, has become active. A large element sensor is difficult to detect micro magnetic particles. As for the detection limit, we confirmed that the newly developed product can detect particle even 5 μm in diameter.

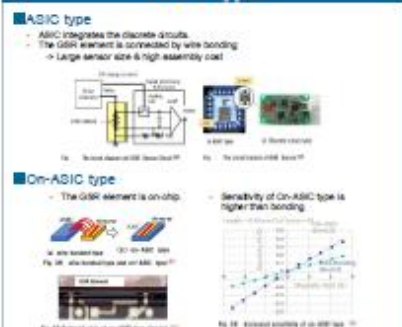
1) Y. Honkura, and S. Honkura, "The development of a micro-wire-on-ASIC type GSR sensor driven by GHz pulse current," *Journal of Magnetism and Magnetic Materials* 573 (2020) 167240.

2) Honkura, Y., and Honkura, S. (2020). The Development of ASIC Type GSR Sensor Driven by GHz Pulse Current. *Sensors*, 20(4), 1023. <https://doi.org/10.3390/s20041023>

Introduction



ASIC type

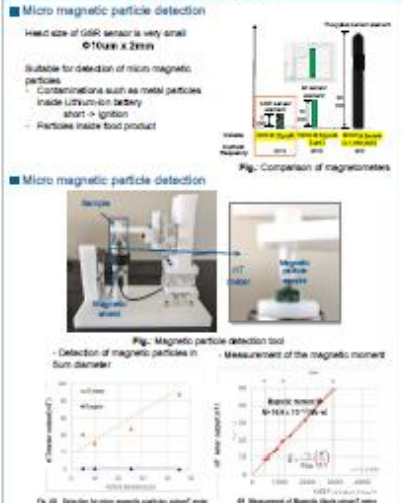


Application

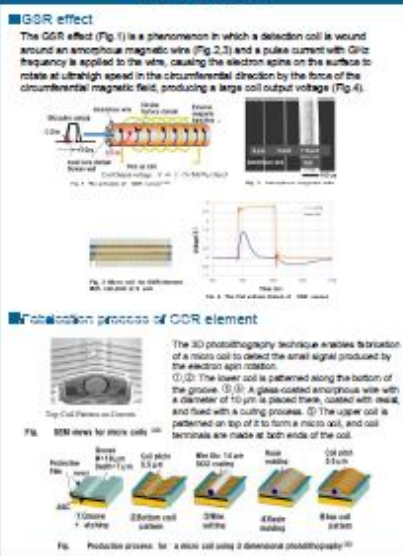
GSR sensors, ultra-compact high-sensitivity magnetic sensors, are being developed for sensor applications in all IoT fields.

- ✓ Motor control fields (Encoders, current sensors)
- ✓ Information technology (navigation, motion sensors, and driverless vehicles)
- ✓ Biological fields (biomagnetic detection devices, in-body mobile devices)

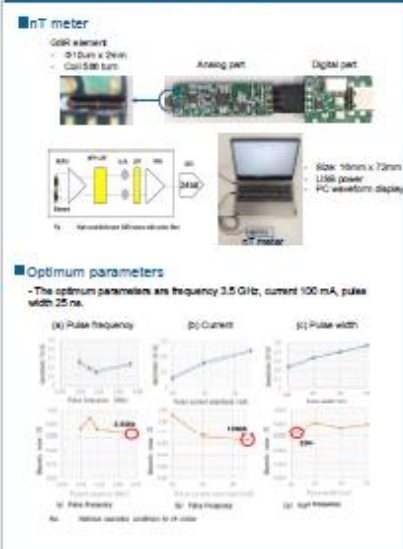
Application



GSR sensor



nT meter



Application



Conclusion

The GSR sensor detects the rotation of electron spins on the surface of an amorphous wire by GHz pulses with a detection coil, which is based on Co-based amorphous wire with a diameter of 5 to 10 μm and coil pitch of 2 μm.

- We have succeeded in developing an on-ASIC type GSR sensor that directly forms elements on the surface of the sensor.
- There is a growing need for ultra-sensitive micro magnetic sensors for applications in the automotive and robotics fields, digital mobile devices such as smart watches, medical fields, and electronically controlled motors.
- We have developed the nT meter, the magnetic noise <0.7 nT (DC-500Hz).
- The nT meter can detect the micro magnetic particle of 5 μm diameter.
- The development of innovative magnetic sensor products utilizing GSR sensors is expected in the future.

The instruments of "nT meter" and "Micro particle detection" are demonstrated at a booth during this conference.

Improvement of Absorption Force of Magnetic Attachment by utilizing Stainless Steel (SUS)-Magnets

C. Mishima, T.Mitsunaga, Y.Honkura
MagneDesign Corporation

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・In response to the aging society and the results of the 8020 movement (20 sound teeth remaining at age 80 in Japan), the development of a new magnetic bridge denture utilizing healthy teeth is expected.

・Conventional Magnetic Attachments were 2.1 mm thick (600 gf of Absorption Force), making it difficult to apply them to healthy teeth. Generally, the thickness of enamel of healthy teeth is 1.2 mm or less (Fig.1).

・Furthermore, conventional Attachments have the problem that during MRI diagnosis, the MRI image is distorted by a Diameter of 80mm (artifact) as shown in the photo (Fig.2).

・We started to develop a **Thin Magnetic Attachment** based on the assumption that the thickness of the teeth enamel is less than 1mm.



Target: Develop Thin Magnetic Attachment with thickness of 0.6mm, Adsorption Force of 600gf or more, and cost of less than 1000 yen(\$7)

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2. Discovery of the Stainless steel (SUS)-Magnets

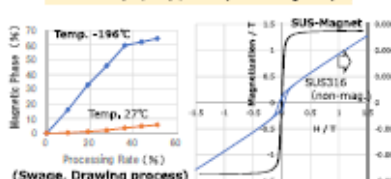
2.1 Magnetization of Austenitic Stainless Steel (SUS316)

SUS316: Austenitic Stainless steel

Transformation to magnetic material at -196°C (Liq. N₂), 50 % (Processing rate)



(SUS316) Non-Magnetic



- ・Non-magnetic SUS316 transformed into SUS-Magnet by low temperature processing.
- ・We refer to magnets fabricated from non-magnetic SUS316 as **SUS-Magnets**.
- ・The Properties of the SUS-Magnets: $J_s: 1.37\text{T}$, $H_c: 4\sim 14\text{kA/m}$.
- ・SUS-Magnets are important magnets in the medical field.

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2.2 Microstructure of SUS-Magnets

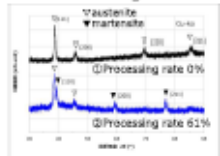
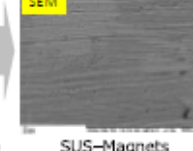
① Processing rate 0%

② Processing rate 61%

XRD change

SEM

SEM



Confirmation of the presence of martensite (α') phase

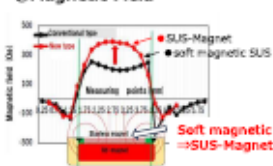
SUS-Magnets form a **fibrous composite structure** consisting of two phases, α' (magnetic) and γ (non-magnetic).

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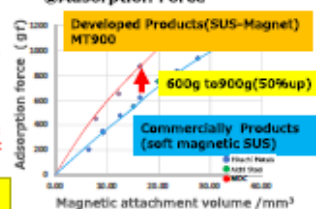
2.3. Effects of Applying SUS-Magnets to Dental Attachments

① Magnetic Field

② Adsorption Force



The Magnetic Field in the center of the SUS-Magnet is **increased**.
-Soft SUS: center curves down
-SUS-Magnet: center curves up



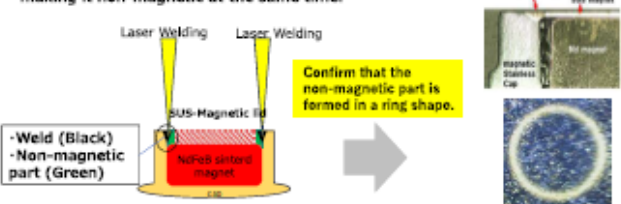
SUS-Magnet increases Adsorption Force.

The use of SUS-Magnets makes the developed product **1.5 times more powerful** than commercial products.

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③ Process Simplification

・Consider the possibility of Laser Welding the lid and making it non-magnetic at the same time.



Non-magnetic modification is possible with the heat from **Laser Welding**.
⇒ By using SUS-Magnets, the **Process** can be **simplified** by combining the non-magnetic modification process with the welding process.

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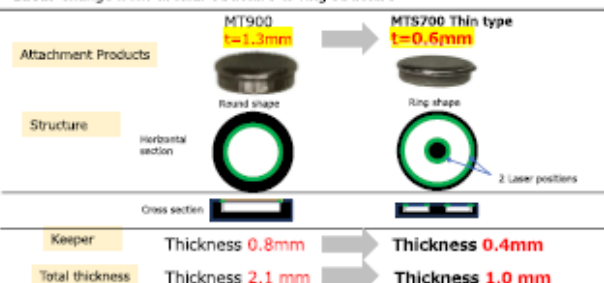
3. Development Targets

Development of thin magnetic attachments thickness $1.3 \Rightarrow 0.6\text{ mm}$

・(Thin Magnetic Attachment) Targets:

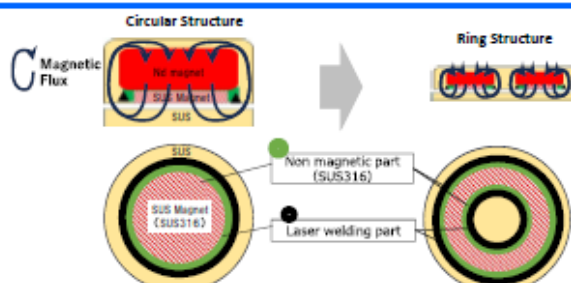
Diameter is 4mm, thickness is 0.6mm, keeper thickness is 0.4mm

・Idea: Change from circular structure to ring structure



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4. Idea of Magnetic Circuit



By making the magnet in the **shape of a ring**, the Adsorption Force is increased by **parallelization of the Magnetic Circuit**.

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5. Experimental Procedure



5.1 Materials

Part Name	Material	Shape / mm
Cap	SUS 436S	Outer diameter : $\Phi 47.0$, Inner Diameter : $\Phi 3.60$, Thickness : 0.62 Center diameter : $\Phi 1.60$
Lid	SUS 316	Outer diameter : $\Phi 1.66$, Inner Diameter : $\Phi 1.60$, Thickness : 0.12
Magnet	Nd-Fe-B Sintered magnet (N52)	Outer diameter : $\Phi 3.50$, Inner Diameter : $\Phi 1.70$, Thickness : 0.35



5.2 Three-Part Fabrication Process

Cap			SUS-Magnets Lid			Magnet		
Process name	Material	Cap inner processing	Material	Drilling machine	Centerless processing	Drilling	Cutting	LM Polishing
Equipment used	SUS 436S	Pressing Machine	SUS 316	Drilling Machine	Centerless grinding Machine	Electric discharge Machine	Hull wire cutting Machine	Grinding Machine
Attachment parts & Accessories								

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5. Experimental Procedure



5.3 Magnetic Force Measurement

- Measuring Equipment: Gaussmeter
- Measure the magnetic force by moving 0.25mm each sideways.



5.4 Adsorption Force Measurement

- Measuring equipment: Tensile testing machine (IMADA ZTS-50N)
- Attachment body and keeper are glued to an acrylic rod, and the maximum value of tensile load is measured.

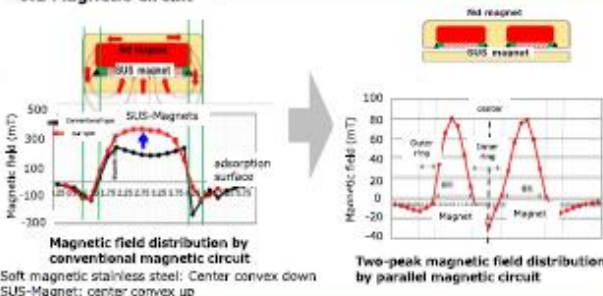


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6. Experimental Results



6.1 Magnetic Circuit



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6.2 Improved Adsorption Force



Thin type Attachments (Product name : MTS700) developed using SUS-Magnets has 2.5 times higher performance than commercial products.

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6.3 Problems and solutions during MRI examinations



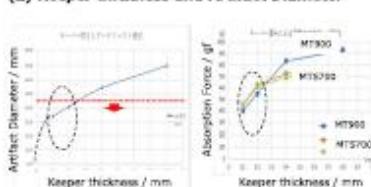
(1)Artifact



Thin Attachment will be 2.8 to 3.5 cm

For the first time in the world, the MRI problem(Artifact) of Magnetic Attachments has been solved.

(2) Keeper thickness and Artifact Diameter



The Thin Attachment can achieve a force of about 500 gf even at 0.1 to 0.2 mm(keeper).

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7. Introduction of Developed Products (MTS 700 Catalog)



MagTeeth - S700 (Newest product)

Features

- High adsorption force and 3 times thinner product by stainless magnets and ring structure
- Highly durable and long life span by using SUS-Magnets and ring structure
- Excellent corrosion resistance by using stainless steel with SUS 316 and SUS 304

Applications

- Removable dental bridge
- Removable denture
- Removable denture
- Removable denture

By using SUS-Magnets and a ring structure, Adsorption Force is maintained and

- (1) thickness is reduced by half
- (2) process is simplified and cost is greatly reduced.

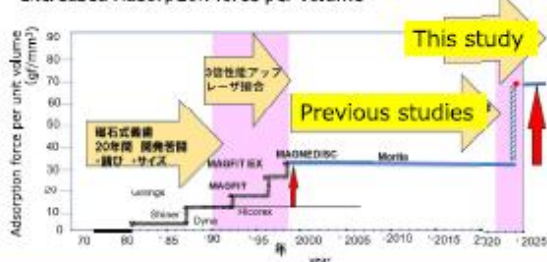
New treatment for removable bridges is available.

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8. Technological Advances in Magnetic Attachments



Increased Adsorption force per unit volume



First Improvement in 30 years with the Application of SUS-Magnets

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9. Summary



1. Adsorption Force is 1.5 times stronger than conventional attachments by using SUS-Magnets in the lid component.
2. Thinned down from 1.3mm to 0.6mm by adopting a ring-shaped structure.
3. Laser non-magnetic modification technology simplifies the process and reduces costs.
4. Applicable to diagnosis by MRI
5. Sales started in Indonesia in March 2024.

Acknowledgement: This research was supported by the "New Aichi Creative R&D Grant Project (Number 47 in 2023)".

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