# HV insulator development status

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# Ceramic Tube Development Kickoff Meeting

- On September 28th, Carlos-san visited KEK, and discussions were held with Kyocera members.
- Taking into account Kyocera's previous accomplishments, this year's budget, and delivery schedule, the decision was made to initially proceed with the prototyping of the R28 Inverted-type ceramic tube.

Kyocera-manufactured (commercially available) 30kV high-voltage Inverted-type feedthrough.

# Ceramic Material Candidates

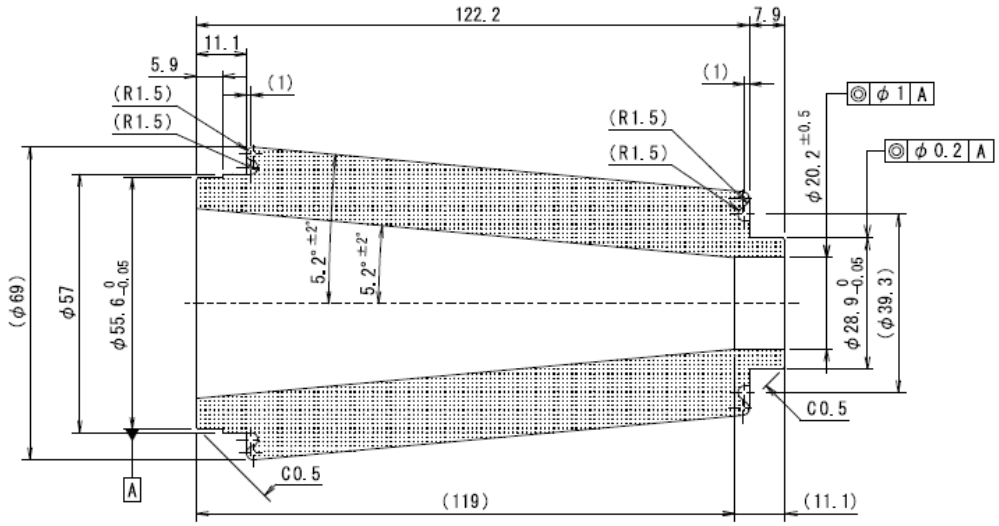
https://global.kyocera.com/prdct/fc/lp/technologies012/index.html

| Material Material Code | | | | High Voltage-resistant Alumina Ceramics | (Conventional) Alumina |
|---|---|---|---|---|---|
| | | | | AH100A | AO479O |
| Electrical Characteristics | Attained Electric Field Strength | | MV/m | 14.1 (ave.) | 8.4 (ave.) |
| | Penetration Dielectric Resistance | | MV/m | 24 | 19 |
| | Volume Resistivity | 20℃ | Ω・cm | ≧$10^{14}$ | ＞$10^{14}$ |
| | Dielectric Constant (1MHz) | | - | 10.2 | 9.9 |
| | Dielectric Loss Angle (1MHz) | | (x $10^{-4}$) | ＜1 | 2 |
| Mechanical Characteristics | Flexural Strength (3-point Bending) | | MPa | 330 | 310 |
| | Young's Modulus of Elasticity | | GPa | 380 | 360 |
| | Poisson's Ratio | | - | 0.25 | 0.23 |
| | Fracture Toughness (SEPB) | | MPa・$m^{1/2}$ | 5 | 3～4 |
| Thermal Characteristics | Thermal Conductivity | 20℃ | W/(m・K) | 24 | 29 |
| | Coefficient of Linear Thermal Expansion (RT-800℃) | | × $10^{-6}$/K | 8.2 | 8.0 |

Due to differences in shrinkage during sintering after CIP between AH100A and AO479M, molds for the same shape will be different after sintering. Additionally, the metallization and brazing methods also differ, making these processes separate even for the same shape.

# Development Scope and Plans for the Current Fiscal Year (1)

1. The firing of only the insulator part of the R28 ceramic tube, with delivery by the end of March.
   - The shape is the same as the R28 Inverted-type ceramic tube produced by JLAB.
   - Two pieces will be made from AH100A material, and one from AO479M material. The delivery time is five months after finalizing the drawings (order process is already completed).
   - The current drawings indicate slight differences in the dimensions of the brazing part due to different brazing methods for AH100A and AO479M materials (final drawings are currently being created).
   - Since there was no budget or time to create a core mold, it will be shaped by machining after Cold Isostatic Press (CIP).




preliminary drawing by Kyocera

# Development Scope and Plans for the Current Fiscal Year (2)

2. Production of Samples for Static Charge Evaluation.
   - Collaboration with the University of Tsukuba and Saitama University is planned to measure the static charge on the ceramic surface after applying high voltage.
   - There will be two types of samples for each of AH100A and AO479M materials, one machining after CIP and one without machining, making a total of four types.

Excerpted from the abstract of Dr. A. Ogura's presentation at IVESC2023, titled "Evaluation of sheet resistance and surface charge of TiO2-coated alumina insulator."

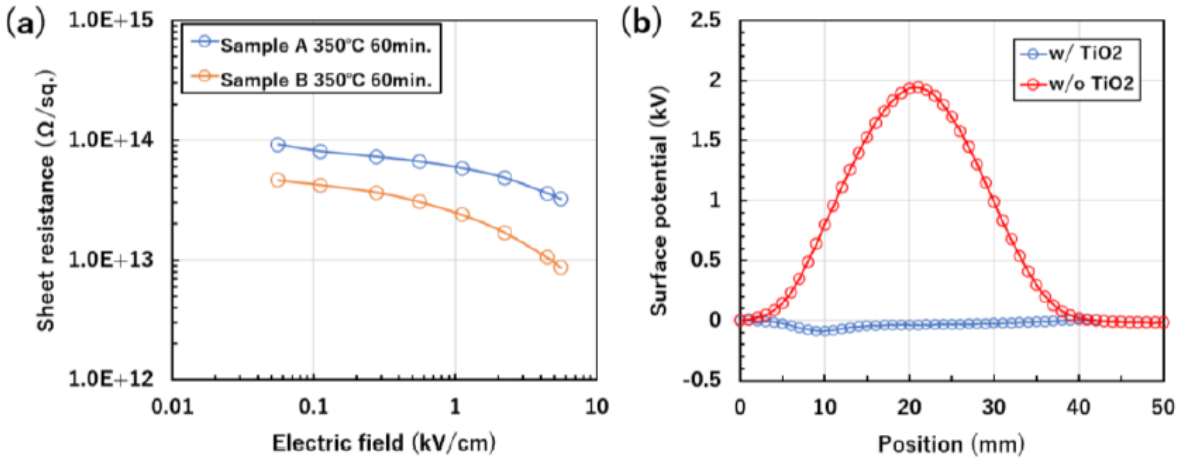
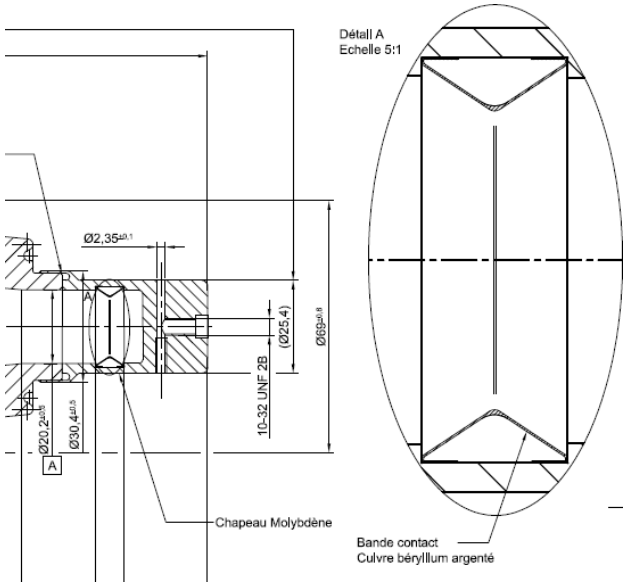



Figure 1. (a) The electric field dependence of the sheet resistance of two $Al_2O_3$ substrates coated with $TiO_2$. (b) Surface potential profiles of $Al_2O_3$ substrates with and without $TiO_2$ coating.

# Research and Development Plans for Subsequent Fiscal Years (1)

1. Production of R28 ceramic tubes (utilizing ceramics produced in the current fiscal year).
   - The ceramics produced in this fiscal year will be prepared for high voltage testing by implementing metallization, brazing, and welding.
   - Estimation drawings are in progress. The brazing parts differ slightly from JLAB's ceramic tubes, and a Kovar socket is expected to be inserted.
   - Once completed, one ceramic tube each of AH100A and AO479M materials will be transported to JLAB.
   - Export procedures will be requested from KEK's administrative side.

[Inquiries]
- We would like information about the specifications, standards, and sources for BeCu springs that receive the R28 connector's tip.
- When making ceramic tubes with AH100A and AO479M materials, we plan to engrave the flange parts to distinguish them. Please specify the location for engraving.



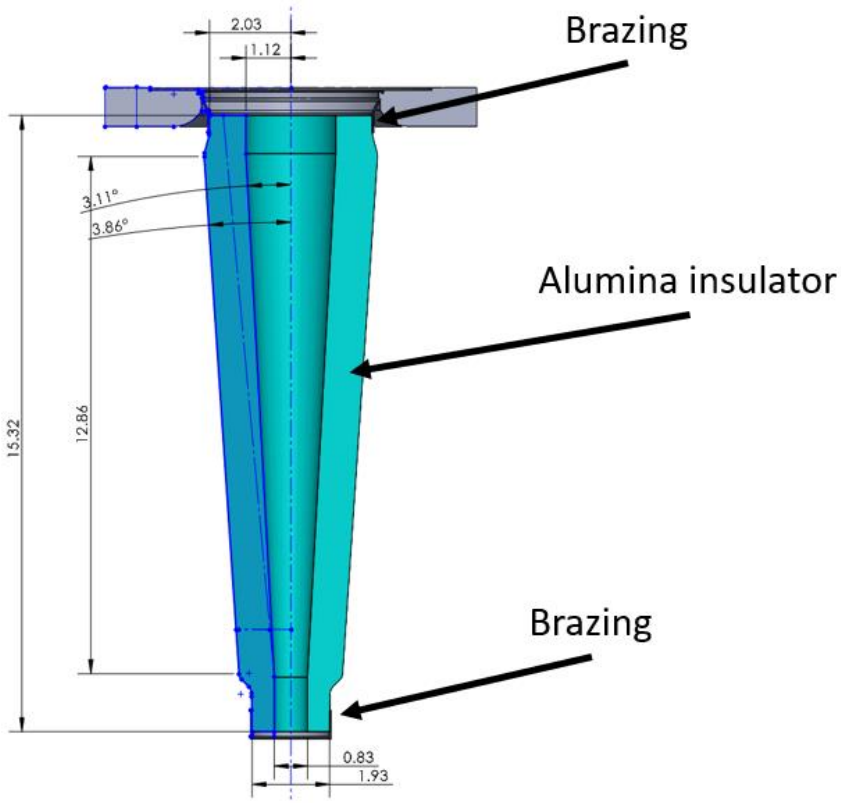
# Research and Development Plans for Subsequent Fiscal Years (2)

2. Conducting static charge evaluation experiments
   - Evaluate the four types of samples created in this fiscal year with a static charge evaluation device (applying a voltage of approximately several kV).
   - Consider modifications to the evaluation device to allow for higher voltage application (equivalent to several tens of kV or more).
   - In particular, consider the shield electrodes for the triple junctions at both ends of the samples, produce the necessary electrodes, and install them.
     - Preparation of probes, vacuum gauges, and electrode fabrication costs.

3. Production of R28 ceramic tubes using a core mold.
   - Sintering without machining after CIP. This may result in a smoother surface compared to cutting, potentially improving the surface discharge characteristics.
   - Consider two types of materials, AH100A and AO479M. An estimation is progressing. (expected response in November).
   - Prioritize AH100A material. (If the budget is limited.)

# Research and Development Plans for Subsequent Fiscal Years (3)

4. Preparation for the development of 500kV high-voltage Inverted-type ceramic tubes.
   - Proposed as part of the R&D content for the second year and beyond.
   - Prototype insulators at full scale. Assess if the required dimensional accuracy is achieved after sintering, using a Try & Error approach.
   - Prepare samples for brazing tests and establish the integrity of brazing, especially for the large-diameter parts.
   - By the end of November, we will ask Kyocera to provide us with a list of development items and their estimated costs that will be required before the fabrication of the actual 500kV high-voltage ceramic tube.

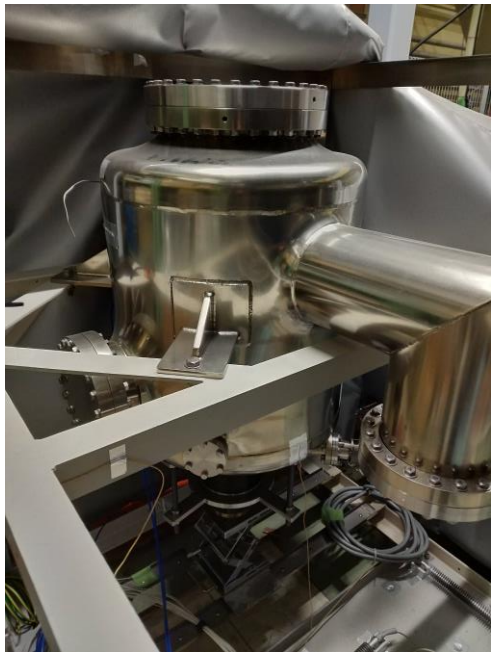



500kV inverted ceramic shape drawing provided by JLAB

# Research and Development Plans for Subsequent Fiscal Years (4)

5. Preparation of high-voltage testing equipment for Inverted-type ceramic tubes in Japan
   - In the process of estimating a DC high-voltage power supply for R28 cable output.
   - If it is difficult to purchase a high-voltage power supply, consider repurposing a DC power supply with a maximum of 250kV, 1mA.
   - Special receptacles for connecting R28 cables will be required from the power output section.


250 kV high-voltage power supply for spin-polarized electron gun



A large UHV chamber made of titanium

# Addition of Collaborative Researchers

From photos of participation in IVESC2023 (September 26-29).

Dr. Akio Ogura
from the University of Tsukuba

Associate Professor Yasushi Yamano
from Saitama University

They will be added to the membership as Japanese collaborators on ceramic tube development.