doi : 10.17596/0004011

R/V *Yokosuka* Cruise Report

YK24-17C

Basic characteristic evaluation for laser direct joining of difficult-to-adhere composite materials to light metals in the deep sea

Central Okinawa Trough

10th Nov. 2024 – 17th Nov. 2024

Japan Agency for Marine-Earth Science and Technology
(JAMSTEC)

Contents

1. Cruise Information

● Cruise ID: YK24-17C

● Name of vessel: R/V *Yokosuka*

● Title of cruise: Basic characteristic evaluation for laser direct joining of difficult-to-adhere composite materials to light metals in the deep sea

● Chief Scientist [Affiliation]: Kazuya Kitada [JAMSTEC]

● Cruise period: 10th Nov. 2024 to 17th Nov. 2024

● Ports of departure and arrival: Yokosuka HQ to Yokosuka HQ, JAMSTEC

● Research area: Iheya-North Knoll, the southern flank of Iheya Minor Ridge and Izena Hole at the Central Okinawa Trough

● Research map:

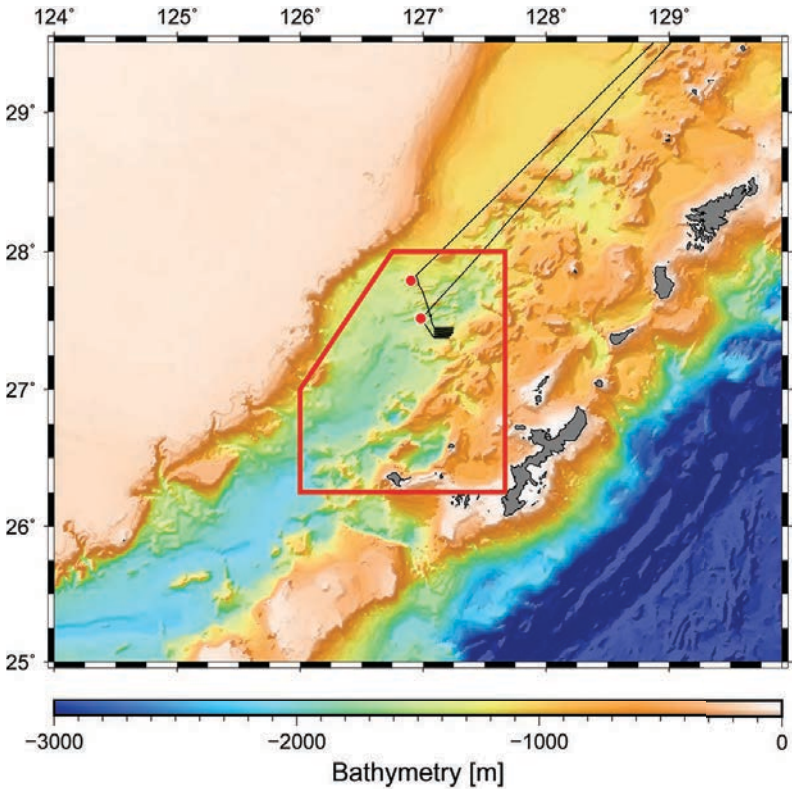

Fig. 1-1 Survey area and ship track during the YK24-17C cruise.

2. Research Proposal, Science Party and Crew

● Title of proposal:

Basic characteristic evaluation for laser direct joining of difficult-to-adhere composite materials to light metals in the deep sea (2/2)

● Representative of the Science Party [Affiliation]

Yosuke Kawahito [JAMSTEC]

● Science Party (List) [Affiliation, assignment etc.]

Kazuya Kitada [JAMSTEC]
Tsuyoshi Nakamura [JAMSTEC]
Hitomi Tonosaki [JAMSTEC]

● R/V *Yokosuka* crew members:

Captain	Takafumi Aoki
Chief Officer	Ryo Yamaguchi
2nd Officer	Keisuke Kusumi
3rd Officer	Yuto Obata
Jr.3rd Officer	Rindo Sakamoto
Chief Engineer	Minoru Tsukada
1st Engineer	Daisuke Gibu
2nd Engineer	Katsuto Yamaguchi
3rd Engineer	Koki Shimizu
Chief Electronic Op.	Takayuki Mabara
2nd Electronic Op.	Ryuji Onikubo
Boatswain	Naoki Iwasaki
Quarter Master	Tsuyoshi Chimoto
Quarter Master	Hotaka Honjo
Quarter Master	Shinya Kojima
Sailor	Taisei Matsuda
Sailor	Mizuki Nakano
Sailor	Yudai Nagamine
No.1 Oiler	Junji Mori
Oiler	Katsuyuki Miyazaki
Oiler	Daiki Sato
Oiler	Toru Hidaka
Assistant Oiler	Kenzo Ochiai
Chief Steward	Toru Murakami

Steward	Toshiyuki Asano
Steward	Tatsuya Shiraishi
Steward	Mizuki Nakano
Steward	Keito Sato

● **HOV *Shinkai 6500* operating team:**

Submersible Operation Manager	Kazuhiro Chiba
Deputy Submersible Op. Manager	Tomoe Kondo
1st Submersible Staff	Mitsuhiro Ueki
1st Submersible Staff	Akihisa Ishikawa
1st Submersible Staff	Takuma Onishi
2nd Submersible Staff	Hirofumi Ueki
2nd Submersible Staff	Keigo Suzuki
2nd Submersible Staff	Ryo Saigo
2nd Submersible Staff	Satsuki Iijima
2nd Submersible Staff	Motohiro Matsusaka
3rd Submersible Staff	Kaisei Sato
3rd Submersible Staff	Tomoka Eda

● **Marine Technician:**

Chief Observation Engineer	Hisanori Iwamoto
Observation Engineer	Kohei Ikeda
Observation Engineer	Haruna Yamanaka

3. Observations

3.1 Objectives & Background

Poly-Ether-Ether-Ketone (PEEK) - Carbon Fiber Reinforced Plastics (CFRP) composite is expected to be suitable for drone taxis, space elevators, next-generation aircraft, and deep-sea submarines. This research has the potential to contribute to their applications significantly. However, bonding PEEK-CFRP to metal using conventional adhesives proves challenging due to its chemical structure. Therefore, a new dissimilar material joining technology for PEEK-CFRP and metal is necessary to overcome this adhesion difficulty. Specifically, the metal is assumed to be aluminum alloy, titanium alloy, or magnesium alloy. Laser direct joining, developed by Kawahito et al. in 2008, has garnered attention as one of the potential solutions.

This project elucidates the direct joining mechanism between difficult-to-adhere composites and light metals with a laser through state-of-the-art observation, laboratory analysis, and numerical analysis. Moreover, we achieve joint strength and reliability that can be utilized in space and the deep sea by deriving the dominant joining factors from the peeling process occurring at the joint interface and controlling these factors.

3.2 Dive Information & Preliminary Results

During this cruise, we performed two HOV *SHINKAI 6500* dives in the hydrothermal areas of the Iheya North Knoll and the Iheya Minor Ridge in the Central Okinawa Trough. To evaluate the laser direct joining of difficult-to-adhere composite materials to light metals in the deep sea, we recovered four sets of laser direct joining sample evaluation equipment which were installed on the platform above drilled holes and on the seafloor about 110 meters away from the drilled holes at the Iheya North Knoll during the YK23-07C and YK24-04C cruises. We also conducted in-situ sensor measurements such as temperature, pressure, turbidity and magnetic field, seawater sampling and sediment coring in the vicinity of the evaluation test sites. In addition, regional geophysical surveys (bathymetry, hydrothermal plume survey and magnetic field) were conducted by the R/V *Yokosuka*.

3.2.1 HOV *SHINKAI 6500* Dive 1832 (13th November 2024) at the Original Site, Iheya-North Knoll

Payload:

Thermometer for hydrothermal fluid x 1, Turbidity meter x 1, Niskin water sampler x 2, 3D mapping system x 1, Stand-Alone Heat Flow meter (SAHF) x 1, Three-component magnetometer x 1, Scalar magnetometer x 1

Operation:

After landing on the seafloor, the *SHINKAI 6500* moved to Site-1 to observe the condition of the platform and recovered two sets of laser direct joining sample evaluation equipment (IDs: YK23-07C #3 and YK24-04C #1) on the platform (T_{max} = 310.9 ºC). The *SHINKAI 6500* moved to the artificial hydrothermal vent near Site-1 to observe the condition of the platform and recovered one set of laser direct joining sample evaluation equipment (ID: YK24-04C #2) on the platform (T_{max} = 13.3 ºC). The

SHINKAI 6500 then moved to the 110 m north of Site-1 site and recovered one set of laser direct joining sample evaluation equipment (ID: YK24-04C #3) on the seafloor. Seawater samples were collected at both installed sites (Site-1 and the 110m north of Site-1 site) and geothermal gradients on the seafloor were measured at two sites around Site-1. After the operation, the *SHINKAI 6500* moved to observe the hydrothermal chimneys using a stereo video camera system and measured temperature of the hydrothermal fluids emitted from the chimneys around Site-1.

3.2.2 HOV *SHINKAI 6500* Dive 1833 (14th November 2024) at the southern flank of Iheya Minor Ridge

Payload:

Thermometer for hydrothermal fluid x 1, Turbidity meter x 1, Push corer x 2, 3D mapping system x 1, SAHF x 1, Three-component magnetometer x 1, Scalar magnetometer x 1

Operation:

After landing on the seafloor, the *SHINKAI 6500* moved to the north of Site-2, measured geothermal gradients on the seafloor and collected a sediment sample using a push corer. The *SHINKAI 6500* then moved to the south of Site-2, measured geothermal gradients on the seafloor and collected a sediment sample using a push corer. After the operation, the *SHINKAI 6500* deployed a scalar magnetometer and conducted high-resolution magnetic surveys near the seafloor within an area of 200 m x 600 m. The geomagnetic field was measured using the magnetometer towed ~15m below the *SHINKAI 6500*, with survey line spacing of ~20 m or less over the site.

4. Cruise Log

10-Nov-24	08:00	Scientists boarded.
	09:00	Left Yokosuka HQ, JAMSTEC for research area.
	09:30	Education and training for scientists.
	10:00	*SHINKAI 6500* team and Scientists meeting.
	17:00	Arrived at Suruga Bay to escape adverse sea conditions.
11-Nov-24	04:30	Left Suruga Bay for research area.
12-Nov-24		Transit to research area.
	09:00	Abandon ship drill.
	09:30	*SHINKAI 6500* briefing.
	13:00	*SHINKAI 6500* team and Scientists meeting for Dives #1832 and #1833.
13-Nov-24	06:30	Arrived at research area.
	06:56	Released XBT.
	10:19	*SHINKAI 6500* dove and started her operation dive No.1832.
	10:57	*SHINKAI 6500* landed on the sea bottom.
	15:30	*SHINKAI 6500* left the sea bottom.
	16:23	Recovered *SHINKAI 6500* and finished above operation.
	17:02	Deployed proton magnetometer.
	18:23-18:44	Carried out figure eight turn measurement.
	19:30	Surface geophysical survey.
14-Nov-24	05:02	Finished surface geophysical survey.
	06:59	Recovered proton magnetometer.
	10:19	*SHINKAI 6500* dove and started her operation dive No.1833.
	11:10	*SHINKAI 6500* landed on the sea bottom.
	15:21	*SHINKAI 6500* left the sea bottom.
	16:35	Recovered *SHINKAI 6500* and finished above operation.
	17:30	Left research area for Yokosuka.
15-Nov-24		Transit to Yokosuka.
16-Nov-24		Transit to Yokosuka.
17-Nov-24		Transit to Yokosuka.
	13:30	Arrived at Yokosuka HQ, JAMSTEC.

5. Notice of Use

This cruise report is a preliminary documentation as of the end of cruise.
This report is not necessarily corrected even if there is any inaccurate description (i.e. taxonomic classifications). This report is subject to be revised without notice. Some data on this report may be raw or unprocessed. If you are going to use or refer the data on this report, it is recommended to ask the Chief Scientist for latest status.
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