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R/V *Yokosuka* Cruise Report

YK23-17C

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

Central Okinawa Trough

1st Oct. 2023 – 12th Oct. 2023

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

Contents

1. Cruise Information

● Cruise ID: YK23-17C

● Name of vessel: R/V *Yokosuka*

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

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

● Cruise period: 1st Oct. 2023 to 12th Oct. 2023

● Ports of departure and arrival: Naha to Yokosuka HQ

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

● Research map:

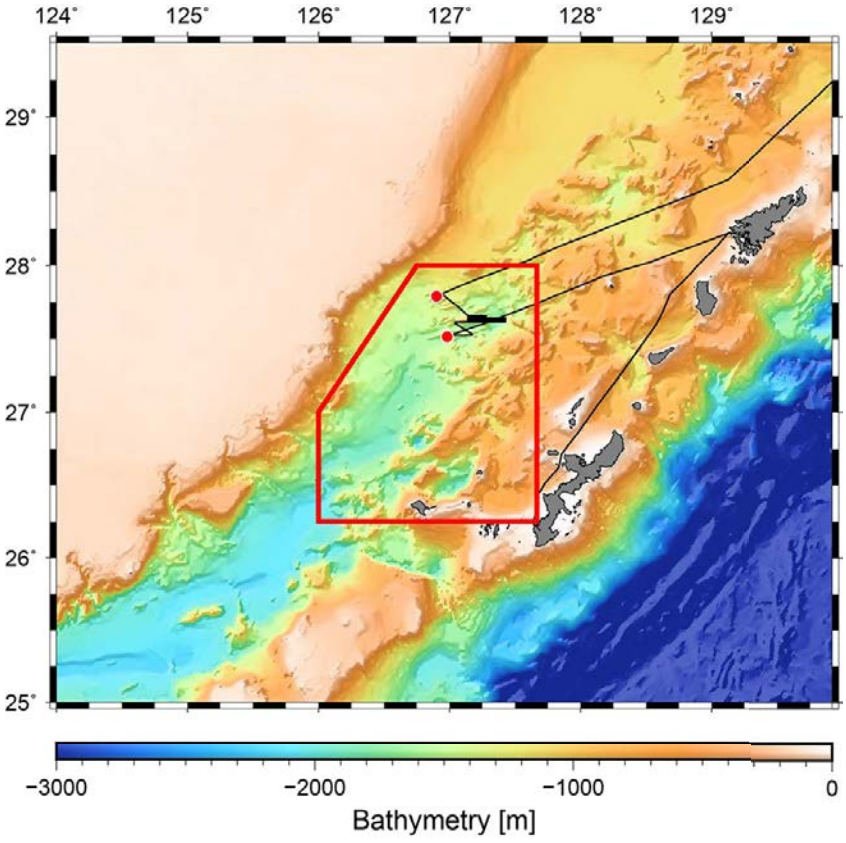

Fig. 1-1 Survey area and ship track during the YK23-17C cruise.

2. Research Proposal, Science Party and Crews

● Title of proposal:

Mechanism elucidation for laser direct joint of difficult-to-adhesive composite materials to light metals and its basic characteristic evaluation

● Representative of the Science Party [Affiliation]

Yosuke Kawahito [JAMSTEC]

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

Kazuya Kitada [JAMSTEC]
Hitomi Tonosaki [JAMSTEC]
Tatsumi Kawafuchi [Hirotec Corp.]
Shungo Imanishi [Hirotec Corp.]

● R/V *Yokosuka* crew members:

Captain	Yoshiyuki Nakamura
Chief Officer	Hiroyuki Kato
2nd Officer	Kanto Asaji
Jr. 2nd Officer	Tomonari Kajisa
3rd Officer	Riku Matsuda
Chief Engineer	Takashi Ota
1st Engineer	Shinichi Ikuta
2nd Engineer	Kota Fujii
3rd Engineer	Yusuke Tomiyama
Chief Electronic Op.	Masamoto Takahashi
2nd Electronic Op.	Takayuki Mabara
Boatswain	Hideo Isobe
Quarter Master	Hiroaki Nagai
Quarter Master	Kenji Nakae
Quarter Master	Shinya Kojima
Quarter Master	Takumi Miura
Sailor	Ryo Nakanishi
Sailor	Shinnosuke Inoue
No.1 Oiler	Masayuki Fujiwara
Oiler	Toru Hidaka
Assistant Oiler	Haruki Matsumoto
Assistant Oiler	Aoi Dantsuka
Assistant Oiler	Kota Matsumura

Chief Steward	Kiyotaka Kosuji
Steward	Seiji Honda
Steward	Kina Abe
Steward	Mizuki Nakano
Steward	Tsugumi Tanaka

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

Submersible Operation Manager	Kazuhiro Chiba
1st Submersible Staff	Tomoe Kondo
1st Submersible Staff	Mitsuhiro Ueki
1st Submersible Staff	Akihisa Ishikawa
1st Submersible Staff	Fumitaka Saito
2nd Submersible Staff	Keigo Suzuki
2nd Submersible Staff	Ryo Saigo
2nd Submersible Staff	Takuma Onishi
2nd Submersible Staff	Yoshikazu Kuramoto
2nd Submersible Staff	Naoto Minamino
3rd Submersible Staff	Motohiro Matsusaka
3rd Submersible Staff	Kaisei Sato

● **Marine Technician:**

Chief Observation Engineer	Hisanori Iwamoto
Observation Engineer	Wataru Tokunaga
Observation Engineer	Michiyasu Katagiri

3. Observations

3.1 Objectives & Background

PEEK-CFRP 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-adhesive composite materials to light metals in the deep sea, we installed four sets of laser direct joining sample evaluation equipment. Two sets were placed at the Iheya North Knoll, and the other two sets were placed at the Iheya Minor Ridge. The equipment was installed on the platform above drilled holes and on the seafloor about 100 - 150 meters away from the drilled holes. All the installed equipment is planned to be recovered during cruises in FY2024. After the installation, we recovered one set of evaluation equipment at the Iheya Minor Ridge. We also conducted in-situ sensor measurements such as temperature, pressure, turbidity and magnetic field, rock sampling, and seawater sampling 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 1732 (7th October 2023) at the southern flank of Iheya Minor Ridge

Payload:

Laser direct joining sample evaluation equipment x 2, Total field magnetometer x 1, Three-component magnetometer x 1, Thermometer for hydrothermal fluid x 1, Turbidity meter x 1, Sample box x 1, Niskin water sampler x 2, 3D mapping system x 1, SAHF x 1

Operation:

After landing on the seafloor, the *SHINKAI 6500* moved to the 140 meters WNE of Site-2 and one set of laser direct joining sample evaluation equipment (ID: YK23-17C #1) was installed on the seafloor. The *SHINKAI 6500* moved to the artificial hydrothermal vent of Site-2 to observe the condition of the platform. One set of laser direct joining sample evaluation equipment (ID: YK23-17C #2) was installed

and the evaluation equipment (ID: YK23-07C #1) was recovered at Site-2 (T_{max} = 76.2 ºC). Seawater samples were collected at both installed sites. After the operation, the *SHINKAI 6500* moved to the Hole C9017A, observed the hydrothermal chimney and the condition of the platform by using a stereo video camera system, and measured the temperature of the hydrothermal fluid (T_{max} = 330.0 ºC). Finally, the *SHINKAI 6500* moved to observe the seafloor, collected five rock samples by manipulator, and measured geothermal gradients on the seafloor around the sites.

3.2.2 HOV *SHINKAI 6500* Dive 1733 (8th October 2023) at the Original Site, Iheya-North Knoll

Payload:

Laser direct joining sample evaluation equipment x 2, Total field magnetometer x 1, Three-component magnetometer x 1, Thermometer for hydrothermal fluid x 1, Turbidity meter x 1, Sample box x 1, Niskin water sampler x 2, 3D mapping system x 1, SAHF x 1

Operation:

After landing on the seafloor, the *SHINKAI 6500* moved to the artificial hydrothermal vent of Site-1 to observe the condition of the platform. One set of laser direct joining sample evaluation equipment (ID: YK23-17C #3) was installed on the platform (T_{max} = 310.0 ºC). The *SHINKAI 6500* moved to the 110m north of Site-1 and one set of laser direct joining sample evaluation equipment (ID: YK23-17C #4) was installed on the seafloor. Seawater samples were collected at both installed sites. After the installation, a dense magnetic survey using a towed magnetometer was conducted around the installed sites.

4. Cruise Log

01-Oct-23	08:00	Scientists onboarded
	09:00	Left Naha for research area
	10:45-11:15	*SHINKAI 6500* team and Scientists meeting
02-Oct-23		Evacuation from typhoon off Koniya
	09:00-10:00	*SHINKAI 6500* briefing
03-Oct-23		Evacuation from typhoon
04-Oct-23		Evacuation from typhoon
05-Oct-23		Evacuation from typhoon
06-Oct-23	11:00	Heave anchor, go for research area
07-Oct-23	10:34	*SHINKAI 6500* dove, and started her operation dive No.1732
	11:20	*SHINKAI 6500* landed on the sea bottom
	16:00	*SHINKAI 6500* left the sea bottom
	17:02	Recovered *SHINKAI 6500*, and finished above operation
	19:32-	Surface geophysical survey
08-Oct-23	05:12	Surface geophysical survey
	10:02	*SHINKAI 6500* dove, and started her operation dive No.1733

	10:44	*SHINKAI 6500* landed on the sea bottom
	12:35	*SHINKAI 6500* left the sea bottom
	13:33	Recovered *SHINKAI 6500*, and finished above operation
	14:30	Left research area
09-Oct-23		Transit to Yokosuka HQ, JAMSTEC
10-Oct-23		Transit to Yokosuka HQ, JAMSTEC
11-Oct-23		Transit to Yokosuka HQ, JAMSTEC
	15:15	Let go anchor at Yokosuka No.4
12-Oct-23	08:00	Heave anchor, go for Yokosuka HQ, JAMSTEC
	09:00	Arrived at Yokosuka HQ, JAMSTEC

5. Notice on Using

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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