【Grant-in-Aid for Scientific Research (S)】

Kiri-origami: origami structures induced by kirigami

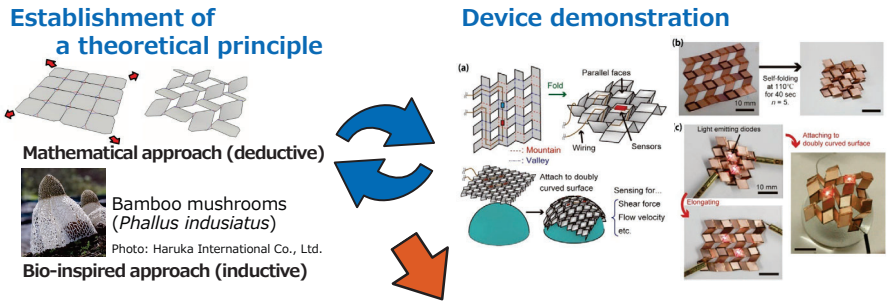
Principal Investigator	Waseda University, Faculty of Science and Engineering, Professor IWASE Eiji　　Researcher Number:70436559
Project Information	Project Number : 22H04954　　Project Period (FY) : 2022-2026 Keywords : origami, kirigami, flexible device, self-folding, kiri-origami structure

Purpose and Background of the Research

●Outline of the Research

This research aims to establish a new academic field of “Kiri-origami structures,” i.e., thin-filmed origami structures realized by the buckling deformation induced by a kirigami structure, through establishing the theoretical principle of Kiri-origami structures and demonstrating devices using them.

The academic field of origami has already been pioneered through “origami engineering,” including space structures deployed over a large area and the strength enhancement of thin sheets by folding. However, it has been shown that conventional origami structures have mode bifurcation in folding that make the structures difficult to be folded from a flat shape even when self-folding techniques with active materials such as heat-shrinkable polymers are applied. In this research, we will construct Kiri-origami structures that structurally induce self-folding by establishing a mathematical model of Kiri-origami structures, propose a design method for cut patterns that express functionality, and demonstrate devices using Kiri-origami structures.



Classification of research areas of origami/kirigami and positioning of this research
((d) and (f) in red are research areas originally proposed and developed by the proposers.)

Figure 1. Overview of this research

● Key Points of the Research

- We focus on the fundamental difference between compression-based origami systems that are difficult to fold into the targeted structure and tension-based kirigami systems that are relatively easy to control.
  ➡ A structure with cutting lines is folded up by macroscopic stretching deformation instead of microscopic and elaborate self-folding.
- We have discovered several origami structures induced by kirigami structures, but the exact mechanism is currently unknown.
  ➡ We have named them “Kiri-origami structures" and will explore them.
- We will fuse kirigami and origami to create a new academic field called “Kiri-origami” and develop “Kiri-origami” into device applications.
  ➡ We will make a new trend next to “origami engineering/origami" and “kirigami.”
- We will solve the "theoretically foldable but difficult to fold in practice" problem of conventional origami structures.
  ➡ We will show the advantages of industrial applications in addition to establishing a theoretical principle.

Expected Research Achievements

●Outline

We plan to conduct research from establishing a theoretical principle to device demonstration of Kiri-origami structures, which are interesting from both academic and industrial application perspectives. Specifically, the research will be divided into three items: The first one is “(A) Establishment of a theoretical principle of Kiri-origami structures,” which promotes the academic aspect of this research. The second one is “(B) Establishment of fabrication and evaluation methods for devices using Kiri-origami structures,” which promotes the engineering aspect of this research. The third one is “(C) Social demonstration of Kiri-origami structured devices,” which promotes the industrial application aspect of this research.

●Key Points

- We create a world-leading team by establishing a theoretical principle, device demonstrations, and industrial applications.
- We form a close linkage between theory, design, simulation, micro/nano-fabrication, and device manufacturing.

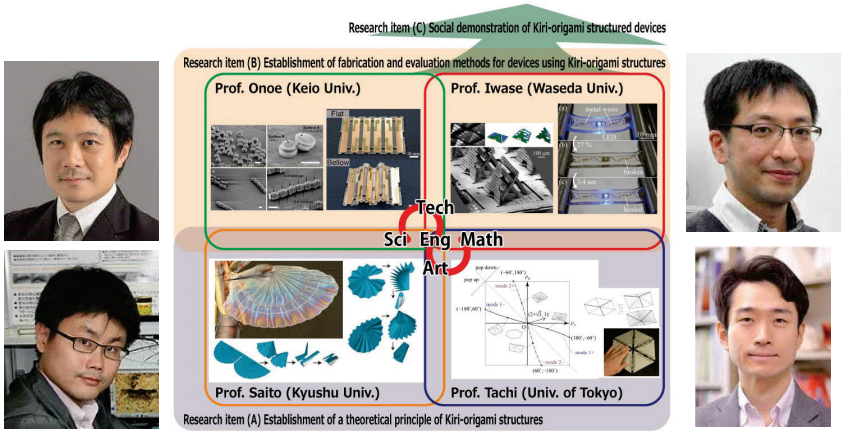


Figure 2. Research members and research items

Homepage Address, etc.	Homepage: https://www.iwaselab.amech.waseda.ac.jp/ Twitter: https://twitter.com/IwaseLab_Waseda