Design of Actuation Performance of a Rubber Metal bimaterial

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Actuators using smart materials offer significant advantages in weight reduction and installation flexibility. This study focuses on the design and mechanical evaluation of a light-driven actuator composed of a rubber-layer and metal layer. While its driving principle is similar to a conventional bimetal[1], this composite utilizes the negative linear expansion coefficient of pre-stretched rubber[2]. This characteristic allows for significantly larger deformation compared to standard metallic bimetals, which is a key advantage for compact robotic applications.

However, the substantial difference in expansion rates between the rubber and metal layers leads to a large deformation condition, making the precise prediction of the force and the defomation highly complex. To address this, loading tests using a horizontal cantilever beam configuration was conducted. The experimental setup is shown in Fig. 1, illustrating the beam's response under thermal loading with external weights. To establish a reliable design framework, a theoretical formulation considering large-scale deflection was considered and compared with Non-linear Finite Element Analysis (FEA). By analyzing the correlation between experimental data and numerical results, we clarified the mechanical behavior of the composite. These findings provide the parameters for the optimal design of this material as a functional, large deformation actuator in practical environments.

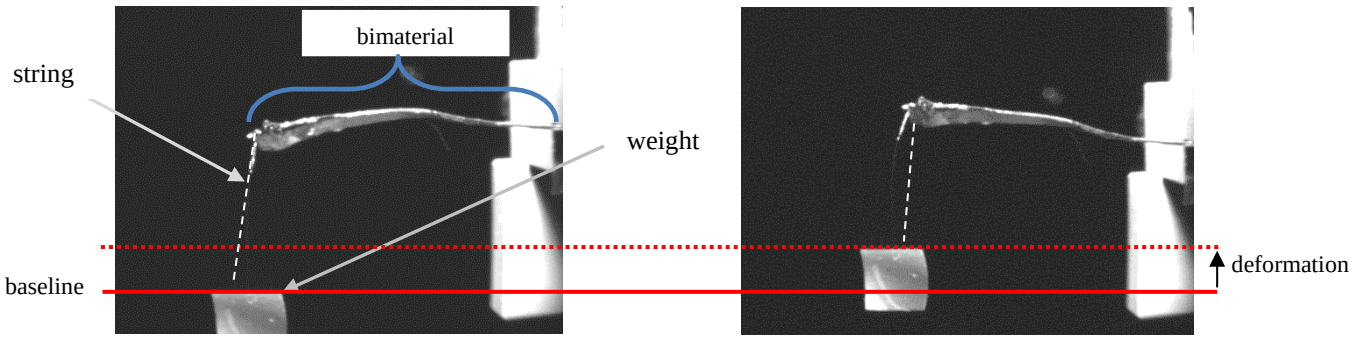

Figure 1. Experimental setup for thermal deformation of a horizontal beam with weight.

(a) before heating, (b) after heating

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