

# Development of an Insect Size Micro Jumping Robot

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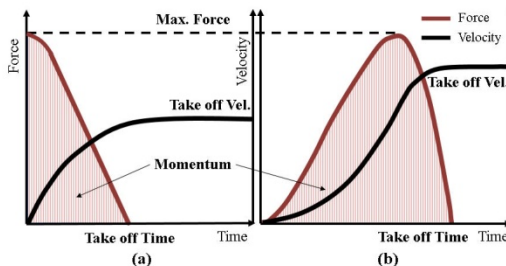
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**Abstract.** An insect size micro jumping mechanism is developed and jumps 40cm. The prototype is fabricated with the composite structures cut by precision UV laser. The robot mechanism is bio-mimetic system that is inspired by the small jumping insect, Flea. A single sheet shape memory alloy coil actuator is used for propulsion and energy storage. The compliant mechanism in the body allows to reduce the number of actuators for triggering. The robot mechanism has 36mg weight, 2 cm length and 2mm height except of wire legs.

**Keywords:** Bio-mimetic robot, SMA actuator, Jumping, Flea.

## 1 Introduction

Jumping is extreme locomotion for a few living creatures and even fine robots. In this research, the flea inspired catapult mechanism is employed to minimize and simplify the energy storage and the triggering structure [1]. The flea has unique catapult mechanism in its anatomy of jumping legs [2]. The flea inspired catapult mechanism generates the force that shows unique profile which is different from spring based jumping legs as shown in fig.1 [3]. The initial force is zero and the force gradually increases while the initial force is maximum in spring legs as shown in fig. 1 (a). We can expect that this profile enhance the momentum transfer of the robot with a constant maximum force.



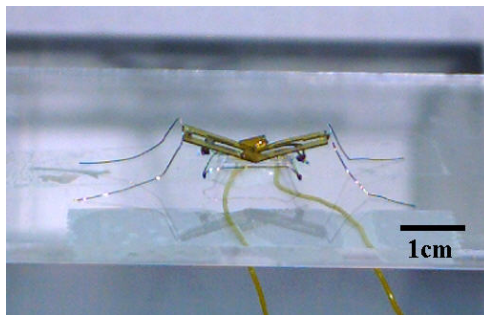
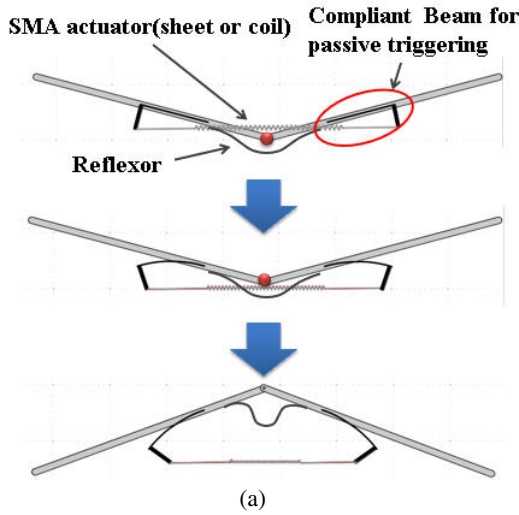
**Fig. 1.** Schematic diagram of the force profile with (a) spring leg and (b) flea inspired catapult mechanism

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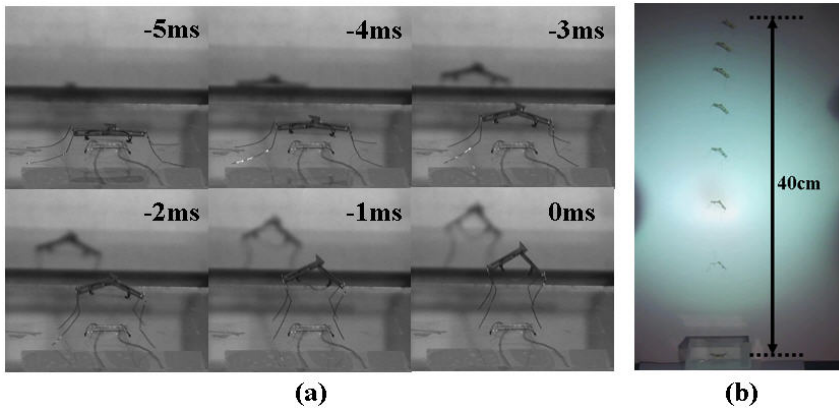
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## 2 Design of Micro Jumping Mechanism

The ultra-light and small jumping robot is designed and fabricated based on the novel composites based robotic structures and the shape memory alloy (SMA) artificial muscle actuators [1]. The robot is bio-mimetic structures that is inspired by the small jumping insect, Flea. The flea inspired catapult mechanism is the torque reversal mechanism that the stored energy is exploded when the force direction of the muscle shifts to the opposite direction respect to the joint as shown in fig. 2 (a).



**Fig. 2.** (a) The triggering procedure of the flea inspired catapult mechanism (b) Prototype of the micro jumping robot



**Fig. 3.** Sequential stop pictures of the jumping motion of the robot prototype

The robot prototype is fabricated by laminating the fiber composite plastic sheets and Polyimide film which are precisely cut by the precision UV laser [4]. Figure 2 (b) shows the prototype of the micro jumping robot. The legs is made of Ni-Cr wires in 200  $\mu\text{m}$  diameter. The prototype has 36mg weight with legs, 2 cm axial length, and 2mm height except the legs.

### 3 Experimental Result

The robot prototype can jump on the ground with heating by the single heat wire. Figure 3 is sequential stop pictures of jumping motion taken by high speed camera in 5000 frame per second. The stored energy can be controlled by designing the compliant trigger and the sheet SMA coil actuator. The jumping height is improved into 40cm high by increasing stored energy compared to the previous prototype presented in Koh *et al.* [1].

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