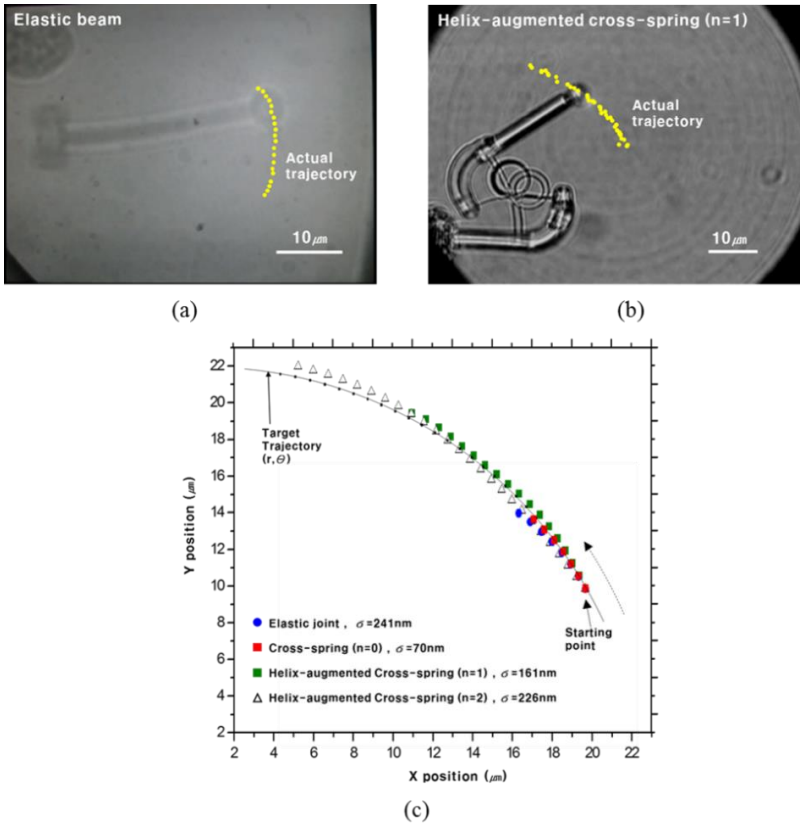

Fig. 6. Actual trajectory of (a) elastic beam and (b) helix-augmented cross-spring. (c) Moving accuracy of the rotational joint compared to the target trajectory.

8. Conclusions

In order to achieve precise rotational movement, a new design of a micro-rotational joint is proposed for precise and reliable rotational movement based on a cross-spring design which incorporates helical structures. With simple equations, it has been found out that the helix-augmented cross-spring can rotate more than a conventional cross-spring without any helical structure. The cross-spring was fabricated by using the two-photon stereolithography system and was manipulated by the optical trapping system. It has been demonstrated that the range of rotational movement can be increased as the number (n) of turns of the helical structure is increased. As compared to the rotational angle of the conventional cross-spring (n = 0), the helix-augmented cross-spring with n = 2 provides 5.1 times the rotational angle. In comparison with the actual trajectory to the circular target trajectory, it was found that the movement of the cross-spring is more accurate than the movement of a simple elastic joint.

It has been found that the proposed micro-rotational joint, helix-augmented cross-spring overcomes the limitations (e.g., motion error and small range of rotational movement) of existing micro-rotational joints. Since the helix-augmented cross-spring has been shown to provide precise, reliable movement; it has a good potential for use in a variety of complex applications such as cell manipulators and fluidic devices.

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