건식 접착 기반 청정 이송장치으로의 적용을 위한 상호 연결형 마이크로필라

Bridged micropillars for the clean transportation system based on fibrillar adhesives

*김두곤 [1], #서갑양 [1,2], 배원규 [2]

*D. Kim[1], #K. Y. Suh(sky4u@snu.ac.kr)[2] , W. G. Bae[2]

[1]서울대학교 기계항공공학부, [2]서울대학교 바이오엔지니어링 협동과정

Key words : fibrillar adhesive, gecko-inspired materials, transportation system

1. Introduction

It has been more than a decade since the mystery of special locomotion ability of gecko lizards – originated from the fibrillar structures spanning from macroscale to nanoscale with hierarchy on the foot – has been discovered and studied. Recently, several approaches for manipulating micropillars to build an additional structure or to locally tune the shape or the material properties of a micropillar have been introduced in order to maximize adhesive functionality, *i.e.* adhesion force, durability, reusability, *etc*. Yet, few studies have been reported to focus on applying fibrillar adhesives for industrial need.

Our group has been put a ceaseless effort to find optimized designs of fibrillar adhesives and appropriate applications to hurdle over technical obstacles in various fields that needs advanced adhesives. Fig. 1 shows two representative examples of fields which we have provided with a better solution to the problems such as side effects from conventional medical skin adhesives caused by chemical substances (biomedical applications) and possibility of surface damage during transportation (industrial applications).

We suggest the practical possibility of applying fibrillar adhesives for industrial use by fabricating bridged micropillars that enables both strong attachment and easy detachment with the help of switching detaching mode and demonstrating the transport system based on the bridged micropillars.

Fig. 1 Images of fibrillar adhesive patch with magnified SEM images and its applications to biomedical need for a better skin adhesive and industrial need for an advanced transportation system that can be used in the precision industry (semiconductor, display, *etc*).

2. Results

As can be seen in Fig. 2, simple micropillars were made from high modulus PDMS of 15 wt% curing agent from the master mold made by conventional photolithography and the fully-cured micropillars were slightly laid on the film manually and carefully detached after a few seconds so that we could transfer a very slight amount of soft liquid PDMS on the heads of prepared micropillars. The inked micropillars were inversely placed onto a Teflon-coated low-surface-energy substrate without application of a pressure, resulting in liquid bridging effect. After curing, the bridged micropillars were detached clearly from the Teflon substrate.

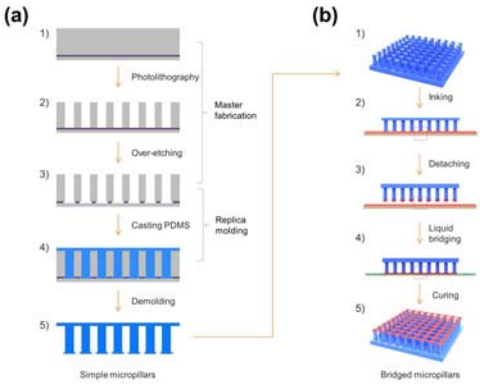

Fig. 2 Schematic illustration for the fabrication of a master mold (a) and bridged micropillars via inking method (b).

The key of successful transportation system is not only to have an enough adhesion force when handling target products but also to realize low adhesion for placing target products where they need to be. By switching detaching methods, it was possible to control macroscopic effective adhesion force with the same fibrillar adhesive; sample of 1 × 1 cm^2 was detached from the glass panels either by pulling the whole sample horizontally in a vertical direction (pulling mode) or by peeling one end of the sample (peeling mode) to reduce the macroscopic adhesion force. The prototype of automated transportation system enabling switching detaching methods was made to demonstrate conveying glass panels for industrial purpose and glass panels of 0.5 kg were successfully conveyed in a vertical direction safely in the pulling mode and released from the system in the peeling mode.

3. Conclusion

We have presented fabricating a reinforced fibrillar adhesive based on bridged micropillars and demonstrating the automated transportation system potentially applicable for industrial use. Fabrication process consists of replica molding via conventional photolithography and post-treatment of replicated simple micropillars by inking method in order to induce liquid bridging effect. Robustness and durability of the fibrillar adhesive based on bridged micropillars were verified to be suitable enough to be applied for industrial use. Finally, a demonstration of automated transportation system was performed to confirm the potential of the dry adhesive in our study for the future industrial application. The fibrillar adhesive composed of bridged micropillars in this study will accelerate the practical use of dry adhesive for various industrial applications such as automated transportation system for highly delicate products.

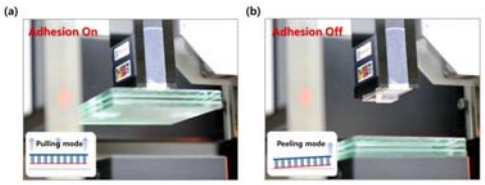

Fig. 3 Demonstration of automated-transportation system based on the fibrillar adhesive. (a) A stack of glass slides was successfully conveyed and (b) released by the system.

후기

We gratefully acknowledge support from the National Research Foundation of Korea (NRF) Grant (no. 20110017530) and WCU (World Class University) program (R31-2008-000-10083-0).

참고문헌

1. Kwak, M. K., Pang, C., Jeong, H. E., Kim, H. N., Yoon, H., Jung, H. S., and Suh, K. Y., “Towards the next level of bioinspired dry adhesives: New designs and applications,” Advanced Functional Materials, **21**, 3606-3616, 2011.