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| 협 찬 | 33개 기관단체

나노종합기술원, 나노코리아, 디에스세미콘, 멤스기술연구조합, 비에스이, 서울대학교 한국 Bio-IT 파운드리 서울센터, 성균관대학교 스마트부품 도금 RIS 사업단, ㈜센플러스, 셀로코 주식회사, 셈소닉, ㈜알트소프트, 에이씨티테크놀로지㈜, 에이엔엠티, 엑사테크, 연세대학교 인체에너지변환 융합파이오니어 연구단, 우원테크놀러지, 주식회사 나우, ㈜에스이테크, ㈜이디앤씨, 지멤스, 지앤피테크놀로지㈜, ㈜케이원솔루션, ㈜펨토사이언스, 프리엠텍, ㈜플리어시스템코리아, 한국과학기술연구원 마이크로나노팹센터, 한국기계연구원 자원절약형 고종횡비 형상 공정기술 기반구축센터 한국이브이그룹 유한회사, 한국전자통신연구원, ㈜항소, 현대건설㈜, IntelliSense, ㈜TUV-SUD KOREA

MICRO ELECTRO MECHANICAL SYSTEMS

2013년도 제15회 한국 MEMS 학술 대회 일정

날짜	시간	내용	장소
4월 4일 목요일	16:00~18:00	등록	로비(그랜드볼룸앞)
	17:30~19:00	리셉션	로비(그랜드볼룸앞)
4월 5일 금요일	07:30~18:00	등록	로비(그랜드볼룸앞)
	08:00~09:20	구두 발표 FO-1 (Bio/Biomimetic MEMS)	그랜드볼룸 좌장: 김상효, 박재성
	09:20~09:30	휴식	
	09:30~09:50	개회식	그랜드볼룸
	09:50~10:20	초청강연 (Invited talk) 이상훈 (고려대학교)	그랜드볼룸 좌장: 이대식, 최낙원
	10:20~11:30	포스터 발표 FP-1	무궁화룸,로즈룸,동백룸 좌장: 임시형, 이정철
	11:30~12:00	특별강연(강관형 교수 추모) 김성재 (서울대학교)	그랜드볼룸 좌장: 서갑양
	12:00~13:20	중식	
	13:20~14:40	구두 발표 FO-2 (Micro Sensors)	그랜드볼룸 좌장: 윤준보, 백창욱
	14:40~15:00	휴식	
	15:00~15:30	초청강연 (Invited talk) 홍병희 (서울대학교)	그랜드볼룸 좌장: 김종백, 박재형
	15:30~16:50	구두발표 FO-3 (Nano/Micro Materials and Fabrication Technology)	그랜드볼룸 좌장: 김준원, 이성호
	16:50~18:00	포스터 발표 FP-2	무궁화룸,로즈룸,동백룸 좌장: 정기훈, 지창현
	18:30~20:30	만찬	그랜드볼룸
4월 6일 토요일	07:30~12:00	등록	로비 (그랜드볼룸앞)
	08:00~09:20	구두발표 SO-4 (Optical MEMS, RF MEMS, Power MEMS and Miscellaneous)	그랜드볼룸 좌장: 박재영, 조일주
	09:20~10:30	포스터 SP-3	무궁화룸,로즈룸,동백룸 좌장: 박정열, 정석
	10:30~11:50	구두발표 SO-5 (Microfluidics)	그랜드볼룸 좌장: 서태석, 한기호
	11:50~12:00	우수논문 시상 및 폐회	그랜드볼룸

Oral Session 2 (FO-2) ⊠Micro Sensors

4월 5일 금요일
13:20 ~ 14:40
좌장: 윤준보, 백창욱

Invited Talk 2

4월 5일 금요일
15:00 ~ 15:30
좌장: 김종백, 박재형

Oral Session 3 (FO-3) ⊠Nano/Micro Materials and Fabrication Technology

4월 5일 금요일
15:30 ~ 16:50
좌장: 김준원, 이성호

Preparation and Characterization of PDMS-based graphene composite for sensor applications

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Abstract

The primary objective of this research is to fabricate the graphene nanopowder composite based on polydimethylsiloxane (PDMS) and characterize the sensitivity of the graphene/PDMS composite. The fabrication of grpahene/PDMS composite can be accomplished by simple and fast sonication and stir processes. The piezoresistive characteristics of graphene/PDMS composite can play the same role as piezoresistor in strain sensors and with the average gauge factors between 6.25 and 277 which obtained within the strain range of 2%. The graphene/PDMS strain sensor showed much higher strain sensitivity than strain sensors and the strain gauge made of other carbon filler composite, the applicability of the composite are demonstrated in this research.

Keywords: ***graphene, composite, strain sensor, piezoresistive***

1. Introduction

Sensors based on nanocomposites have been attracting interest recently due to their strain sensing characteristics. For instance, strain sensors based on CNTs composite [1] [2], carbon black/polymer composite[3], or graphene foam[4] serves as good candidates for developing new hybrid materials-based strain sensors due to their outstanding performance. Graphene, the perfect two-dimensional (2D) crystalline carbon sheet with high Young's modulus and high strength, when used as conductive filler in polymers, graphene not only improve the mechanical properties but also present new functionality. Graphene composites have the potential to realize a higher sensitivity to strain and wider applicability comparing to graphene itself [4] due to the unique superiority of composite and easy to be processed.

Our research demonstrates the preparation and characterization of graphene/PDMS composites for use in strain sensor applications. The piezoresistive property of composites reported as sensing material are of gauge factor value no higher than that demonstrated in our research, which showed great potential for use in MEMS application.

2. Experimental

2.1 Fabrication and measurement of graphene/PDMS composite

The fabrication of graphene/PDMS composite relies on the common evaporation technique[5]. The PDMS (Sylgard 184) was purchased from Dow Corning Co. and the graphene nanopowder (MO-1) from Graphene Supermarket. The appropriate amounts of THF were firstly added into the base polymer to decrease the viscosity of base polymer. The graphene was dispersed into THF with a ratio of 300mg graphene nanopowder per 20ml by using ultrasonicator (ultrasonic power 200W) for 2 hours. Afterwards the dispersed graphene/THF solution was mixed with the base polymer solution by using ultrasonicator for 4 hours to form PDMS base polymer/graphene composite in THF and decrease the macroscopic graphene clusters in the solution. The THF evaporation was processed in a fume hood by stirring the solution at 50℃. The curing agent was added to the dispersed graphene/PDMS base polymer emulsion. Then, the blended graphene/PDMS mixture emulsion was degassed for 30 min. Finally, the mixed composite was uniformly smeared onto 4mm-thick PDMS specimens. In order to fabricate a sensor, the smeared composite was cut into rectangular shape by blades, and cured at 60℃ in oven for 10 h. The final graphene/PDMS composite samples on PDMS specimens have thicknesses between 100 μm and 300 μm. Two electrodes were connected to it with silver conducting epoxy to improve the contact as shown in Fig.1. The perfect bond between PDMS and the composite ensure the transfer of strain across the sensor simultaneous during the measurement.

2.2 Measurement

The piezoresistivity of the composite was investigated with source meter (Keithley 2400). The elongation of the specimen was exerted and measured with universal test machine (SHIMADZU EZ-Test 500N), the loading speed was numerically controlled at 0.5mm/min.

3. Results and discussions

In order to characterize the sensitivity of the graphene/PDMS composite, the gauge factor (GF) of the composite could be obtained with the equation

$$GF = \frac{\frac{\Delta L}{L}}{\frac{\Delta R}{R}} \tag{1}$$

where R is the initial resistance of the sensor and ΔR is the relative resistance change under the deformation. L is the initial length of the sensor and ΔL is the relative elongation of the axial specimen. The relative resistance change of graphene/PDMS composites with different filler concentrations with respect to the applied strain (ε) is shown in Fig.2. The average gauge factors for different concentration of graphene are illustrated in Fig.3 which lies between 6.25 and 277.

The sensitivity can be explained from macro level and micro viewpoint. From a macroscopic point of view, the strain response of graphene/PDMS composites strongly depends on the contact resistance of surrounding graphene flakes. The piezoresistivity may come partly from slippage of graphene flakes in the PDMS matrix which is difficult to measure based on the strain response of the sensor. What is more, the deformation of graphene flakes improves the sensitivity of the composite. Increasing the graphene contact resistance induces the higher resistivity of the composites. Higher strain sensitivity of graphene composites can be explained that the larger inter-contact area among the graphene due to their special 2-D structure. The linear change can also be explained by the fact that the graphene flake bent and extended due to the loading strain and form contacts with multiple adjacent graphene nanopowder. The hysteresis is existed in the composite since PDMS, the viscoelastic polymer matrix with property of elasticity and viscosity, which is presented by a purely viscous damper and purely elastic spring connected in parallel named as Kelvin-Voigt model. The hysteresis is mostly due to the relaxation time of the polymer matrix which results in the shortage for reciprocating strain monitoring applications. The investigation was not systematically performed and further studies on composite flexibility are still needed.

4. Conclusions

This paper reported the fabrication and electromechanical characterization of graphene nanopowder composite based on PDMS. Graphene/PDMS composite shows a linear piezoresistive response with gauge factor between 6.25 and 277 within the strain range of 2%. The high sensitivity which can be explained by the increase of graphene flake contact areas and the deformation of graphene itself, makes it a material with potential to be used for sensing tensile deformation by changes in strain.

Acknowledgment

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References

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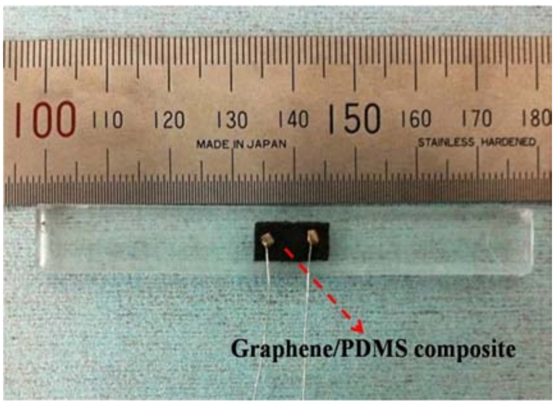

Fig. 1 PDMS Specimen with graphene/PDMS composite for tensile tests

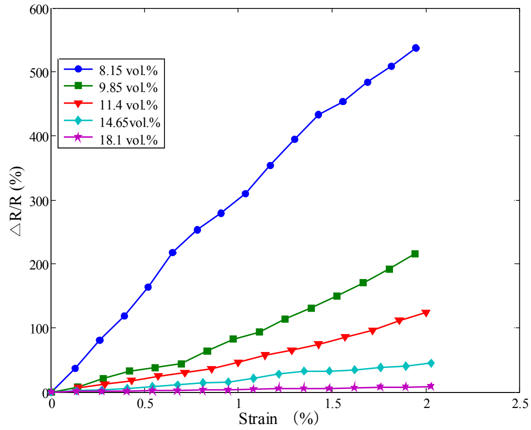

Fig. 2 Composite (with different volume fraction) resistance change with tensile strain

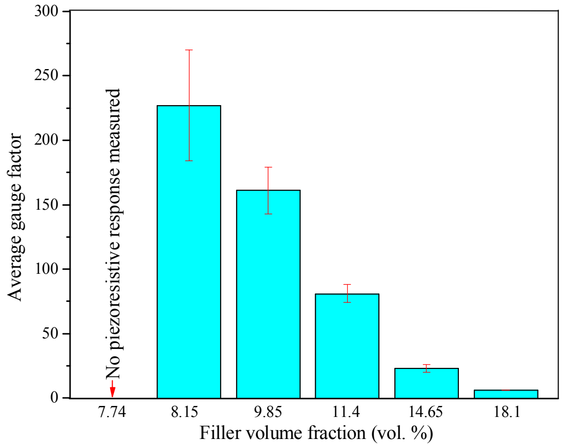

Fig. 3 Average gauge factors of graphene/PDMS composite with different filler volume fraction