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Review: Progress in the Studies on Mechanical Properties of Materials

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Прогресс в исследованиях механических свойств материалов (обзор)

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Материаловедение и инженерия относятся к наиболее актуальным направлениям научных исследований в мире, а применение новых материалов в значительной степени основывается на изучении механических свойств материалов. Исходя из этого в рамках 2-й Глобальной конференции по материаловедению и инженерии 20–22 ноября 2013 года была проведена специальная сессия по вопросам исследования механических свойств материалов. Этот специальный номер содержит подборку из 20 научных работ, отобранных из числа всех докладов, посвященных проблемам структуры, механических свойств и прочности материалов. В данном обзоре обсуждаются отдельные доклады специальной сессии, представленные в этом номере журнала.

Introduction. The Global Conference on Materials Science and Engineering (CMSE) is an annual event starting from 2012. The CMSE 2013 was held by Hubei University of Science and Technology in the city of Xianning (Hubei, China) on November 20–22, 2013. Within this event, a special session named mechanical properties of materials was held. In this session, 31 papers were selected for publication, among which 20 papers are published in this special issue [1–20], two more [21, 22] in the next issue, and 9 papers are published by Materials Research Innovations [23–31]. All papers underwent the standard peer-review process of the journal and were accepted for publication based on the evaluations of at least two independent anonymous reviewers.

Highlighted Papers. The results of study [1] indicate that the crack tip stress distribution characteristics and crack propagation dynamics are closely related to the microstructure evolution caused by the change of the strain rate and temperature. At a lower strain rate and temperature, the crack propagated in a brittle manner without inducing the change of atomic configuration near the crack tip. The stress concentration occurred at the crack tip of a growing crack. The crack propagation exhibited a gradual developing transition from brittle to ductile with increasing temperature and strain rate, the peak stress was accompanied by the appearance of the microstructure evolution ahead of the crack tip.

In paper [3], uniformly distributed TiC nanoparticle-reinforced iron-based composites were successfully prepared by planetary milling in argon and subsequent hot pressing procedures. Nearly full density composite specimens could be obtained via milling for 6 h and follow-up hot pressing at 1100°C under 50 MPa. Comparatively spherical TiC particles and fine fibrous Fe_3C phases were observed in the iron matrix composite. Microstructural analysis results show that the average diameter of TiC particles and the length of Fe_3C phases tend to decrease with the increase of the volume content of TiC.

Her and Wu [7] studied the annealing effect on microstructure and mechanical properties of titanium nitride (TiN) films. By atomic force microscopy they observed that surface roughness of TiN films decreased from 3.83 to 2.43 nm as the annealing temperatures increased from 100 to 300°C. Atomic force microscopy image of the film revealed fine-grained morphology for the TiN annealed at higher temperature. Experimental results showed that the mechanical properties of TiN films could be significantly improved by the annealing process.

Lee et al. [11] presented the results of experimental and analytical studies on the bond strength of glass fiber reinforced polymer bars subjected to monotonic or reversed cyclic load. The test results indicated that the interfacial strength of the GFRP bars was quite different to that of the steel bars. In addition, the degradation of strength of GFRP bars subjected to reversed cyclic load was more severe than that of the GFRP bars subjected to monotonic load.

Feng et al. [4] proposed a new method of fatigue life assessment for TiAl alloys. A typical formula was proposed to describe the interaction force of dislocations. The fatigue life could be improved by the addition of minor elements which result in refinement of grains based on the results of qualitative and quantitative analyses.

Other Papers Published by *Strength of Materials*. In addition to the five above-mentioned papers, 15 more papers are published in this issue and two more in the next issue. The summaries of the papers are as follows:

Li et al. analyzed the fracture behavior of polycrystalline diamond thin films [2]. Sevim et al. studied the effect of aging treatment on surface roughness, mechanical properties and fracture behavior of 6xxx and 7xxx aluminum alloys [5]. Chen et al. studied the flow stress variation of 49MnVS3 non-quenched and tempered steel by conducting the isothermal compression testing on Gleeble-1500D thermal simulated test machine at various temperatures and strain rates [6]. The effects of particle rolling and particle crushing on the evolutions of two kinds of anisotropies, i.e., the anisotropy of particle packing (microstructure) and the anisotropy of force chains, were investigated numerically using the discrete element method (DEM) by Zhou et al. [8]. The effects of SiC particles orientation anisotropy on the tensile properties of spray-formed SiCp/Al-Si composites were investigated and compared with the unreinforced matrix alloy by Li and Chen [9]. Tian et al. studied microstructure and wear resistance of arc-sprayed Fe-based coating after surface remelting treatment, in order to improve the lamellar structure and wear resistance of arc sprayed coatings [10]. Zhong et al. analyzed crack propagation path using an advanced element cracking method [12]. Ni et al. put forward a strength prediction model of particle-reinforced shellproof ceramic composite [13]. Wang and Dong analyzed the thermal stress of honeycomb ceramic regenerator with different parameters, such as holes, porosity and wall thickness [14]. Zhang et al. studied the fatigue life of plow bit under different planning parameters [15]. Fan et al. investigated the tensile strength of composite laminates containing open and filled holes [16]. Han et al. explored the mechanical properties of thermoplastic composite laminations of variable angles for conical shell [17]. Zhu et al. put forward the unified solutions of plastic limit internal pressure for metallic elbows [18]. An et al. studied the cutting-temperature field and distribution of heat rates among workpiece, cutter and chip for high-speed cutting based on analytical and numerical methods [19]. Hu et al. analyzed the dynamic response of the gradient foams [20]. Feng et al. [21] studied influence of temperature on fatigue crack propagation in TiAl alloys, while Khotsyanovskii et al. [22] proposed improvement of strength and thermocyclic creep resistance of metal products with ion-plasma nitride coatings by pulse technique implementation.

Papers Published by *Materials Research Innovations*. Nine more papers accepted in the session of mechanical properties of materials are published by Materials Research Innovations journal [23–31]. Jiang et al. investigated the mechanical behavior of long-span prestressed steel-concrete composite beam [23]. Wang et al. determined the creep characteristics of oil-film bearing babbitt [24]. W. Hu and L. Hu studied the specimen size effects on mode II fracture toughness of concrete [25]. Jia et al. provided the flexural capacity calculation of hybrid bars'-reinforced concrete beams [26]. Yang et al. proposed an analytical method for orange peel structure of aluminum-lithium alloy surface during stretch forming process [27]. Zheng and Liu studied the effect of load and velocity on the wear behavior of a Cu-based self-lubricating composite [28]. Zhu et al. provided the finite element analysis of deformation mechanism for porous materials under fluid-solid interaction [29]. Li et al. studied the flexural toughness of green high-performance fiber-reinforced cementitious composites [30]. Xuan and Guan proposed a smoothed FEM based verification method for the computation of strain energy release rate in functionally graded materials [31].

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Резюме

Матеріалознавство та інженерія відносяться до найбільш актуальних напрямків наукових досліджень у світі, тоді як використання нових матеріалів у значній мірі базується на дослідженні механічних властивостей матеріалів. Виходячи з цього, у межах 2-ї Глобальної конференції з матеріалознавства й інженерії 20–22 листопада 2013 року було проведено спеціальну сесію з питань дослідження механічних властивостей матеріалів. Цей спеціальний номер містить добірку з 20 наукових робіт, відібраних із числа всіх доповідей, присвячених проблемам структури, механічних властивостей і міцності матеріалів. У даному огляді обговорюються окремі доповіді спеціальної сесії, представлені в цьому номері журналу.

1. W. P. Wu and Z. Z. Yao, "Influence of a strain rate and temperature on the crack tip stress and microstructure evolution of monocrystalline nickel: a molecular dynamics simulation," *Strength Mater.*, **46**, No. 2, 164–171 (2014).
2. D. S. Li, D. W. Zuo, and Q. H. Qin, "Analysis of fracture behavior of thin polycrystalline diamond films," *Strength Mater.*, **46**, No. 2, 172–176 (2014).
3. J. M. Kim, J. S. Park, and H. S. Yun, "Microstructure and mechanical properties of TiC nanoparticle-reinforced iron-matrix composites," *Strength Mater.*, **46**, No. 2, 177–182 (2014).
4. R. C. Feng, Z. Y. Rui, G. T. Zhang, et al., "Improved method of fatigue life assessment for TiAl alloys," *Strength Mater.*, **46**, No. 2, 183–189 (2014).
5. I. Sevim, S. Sahih, H. Cug, et al., "Effect of aging treatment on surface roughness, mechanical properties and fracture behavior of 6xxx and 7xxx aluminum alloys," *Strength Mater.*, **46**, No. 2, 190–197 (2014).
6. Y. F. Chen, X. D. Peng, H. B. Xu, et al., "Constitutive equations and processing maps for 49MnVS3 non-quenched and tempered steel," *Strength Mater.*, **46**, No. 2, 198–207 (2014).
7. S. C. Her and C. L. Wu, "Annealing effect on the microstructure and mechanical properties of a thin titanium nitride film," *Strength Mater.*, **46**, No. 2, 208–213 (2014).
8. L. L. Zhou, X. H. Chu, and Y. J. Xu, "Evolution of anisotropy in granular materials: effect of particle rolling and particle crushing," *Strength Mater.*, **46,** No. 2, 214–220 (2014).
9. W. Li, J. Chen, J. J. He, et al. "Effect of SiC particle orientation anisotropy on the tensile properties of spray-formed SiC_p/Al-Si composite," *Strength Mater.*, **46**, No. 2, 221–228 (2014).
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11. J. Y. Lee, K. H. Kim, S. W. Kim, and M. Chang, "Strength degradation of glass fiber reinforced polymer bars subjected to reversed cyclic load," *Strength Mater.*, **46**, No. 2, 235–240 (2014).
12. Z. P. Zhong, Z. W. Jiang, and S. Wan, "Numerical analysis of crack propagation path using an advanced element cracking method," *Strength Mater.*, **46**, No. 2, 241–249 (2014).
13. X. H. Ni, C. Chen, X. Q. Liu, and S. Q. Zhang, "Strength prediction model of a particle-reinforced shellproof ceramic composite," *Strength Mater.*, **46**, No. 2, 250–255 (2014).
14. Y. X. Wang, M. Dong, H. Y. Li, et al. "Study on thermal stress of honeycomb ceramic regenerators with different parameters," *Strength Mater.*, **46**, No. 2, 256–261 (2014).
15. Q. Zhang, M. J. Xu, and N. Hu, "Study on fatigue life of plow bit under different planning parameters," *Strength Mater.*, **46**, No. 2, 262–269 (2014).

16. X. L. Fan, W. J. Qin, and T. Suo, "Experimental investigation on the tensile strength of composite laminates containing open and filled holes," *Strength Mater.*, **46**, No. 2, 270–274 (2014).
17. Z. Y. Han, Y. H. Li, and H. Y. Fu, "Mechanical properties of thermoplastic variable-angle composite laminations for conical shell," *Strength Mater.*, **46**, No. 2, 275–281 (2014).
18. Q. Zhu, J. H. Zhao, C. G. Zhang, et al., "Unified solutions of plastic limit internal pressure for metallic elbows," *Strength Mater*., **46**, No. 2, 282–288 (2014).
19. H. P. An, Z. Y. Rui, R. F Wang, and Z. M. Zhang, "Research on cutting-temperature field and distribution of heat rates between workpiece, cutter and chip for high-speed cutting based on analytical and numerical methods," *Strength Mater*., **46**, No. 2, 289–295 (2014).
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21. R. Feng, Z. Rui, Y. Zuo, et al., "Influence of temperature on fatigue crack propagation in TiAl alloys," *Strength Mater.*, **46**, No. 3 (2014) [in press].
22. A. O. Khotsyanovskii, V. V. Kharchenko, and B. A. Lyashenko, "Improvement of strength and thermocyclic creep resistance of metal products with ion-plasma nitride coatings by pulse technique implementation," *Strength Mater*., **46**, No. 3 (2014) [in press].
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24. J. M. Wang, Y. W. Xue, W. H. Li, et al., "Study on creep characteristics of oil-film bearing babbit," *Mater. Res. Innov.*, **18**, SUPPL. 2, DOI 10.1179/1432891714Z. 000000000490 (2014) [in press].
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30. X. Li, M. Luo, and J. Wang, "Experimental research on the flexural toughness of green high-performance fiber-reinforced cementitious composites (GHPFRCC)," *Mater. Res. Innov*., **18**, SUPPL. 2, DOI 10.1179/1432891714Z.000000000602 (2014) [in press].
31. Z. Xuan and M. Guan, "A smoothed FEM based verification method for the computation of strain energy release rate in functionally graded materials," *Mater. Res. Innov*., **18,** SUPPL. 2 (2014) [in press].

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