

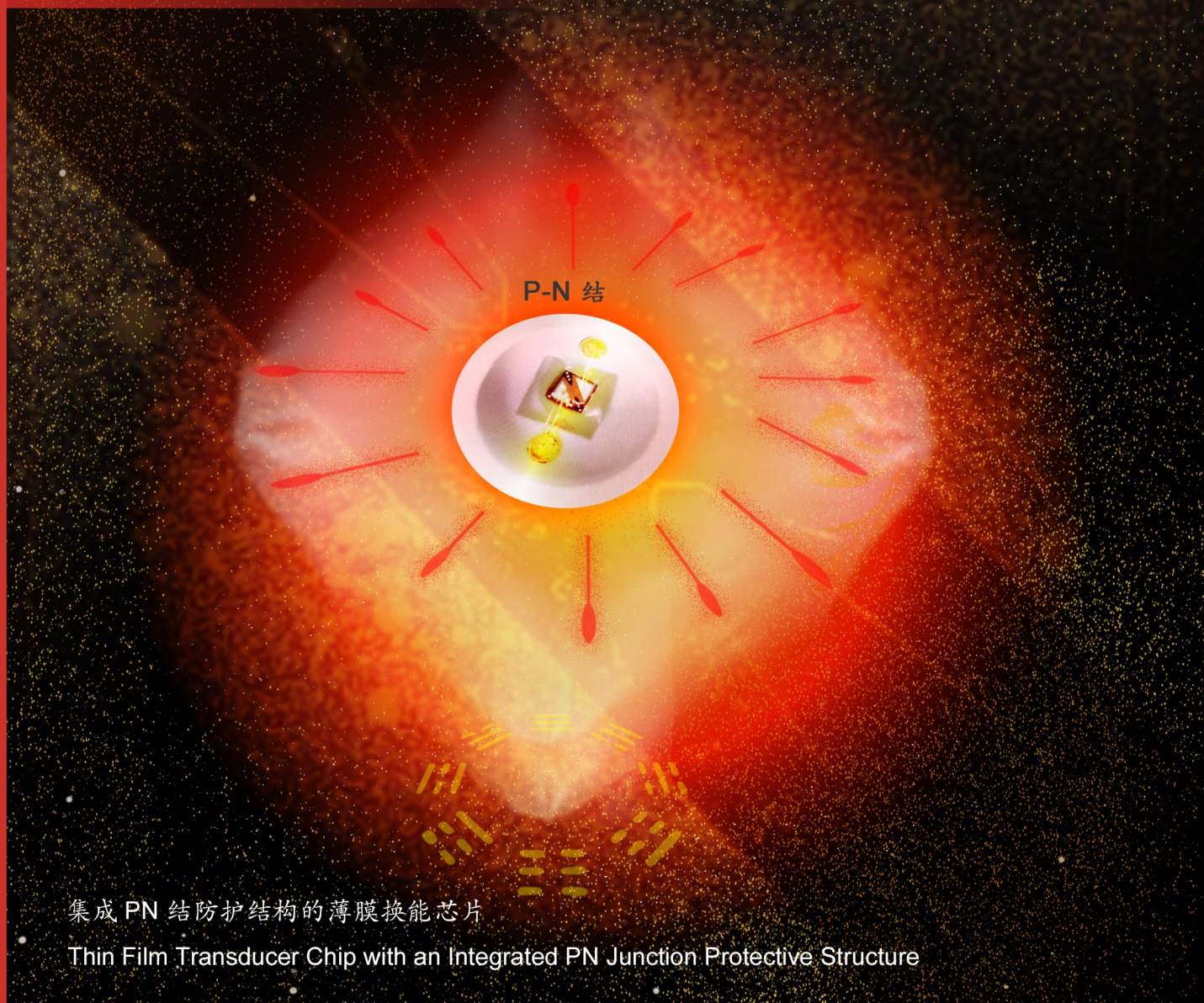
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新型换能器件设计与应用 特邀专题



HANNENG CAILIAO

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特邀 新型换能器件设计与应用 专题

(特邀*)

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彩页 含能巾帼半边天, 开拓奋进新征程

Energetic Material Frontiers 被 Ei Compendex 收录



现代战争中大功率设备的不断增加以及各种新式电子战系统、电子脉冲弹和高功率微波武器的出现,使得战场电磁环境日趋复杂多变,对火工品的抗电磁能力提出了更高的要求。尽管常规火工品薄膜换能元芯片可以达到一般规范需求,但在高安全、高钝感等日益增长的前提下,与新式武器装备的应用要求还有一定差距。基于 MEMS 技术的火工品薄膜换能芯片,由于是硅基微电子工艺加工,更容易实现薄膜芯片和功能电路的单片集成,以及与火工品结构的匹配,因此可以一体化集成芯片设计,同时提高换能元的安全性与可靠性。来自杭州电子科技大学的李慧,骆建军等研究人员提出了一种平面纵向集成 PN 结静电防护电路的薄膜换能芯片,基于微电子技术进行了火工品用薄膜换能元与功能电路的集成设计与制作,本设计既提高了薄膜芯片抗静电、抗电磁脉冲的能力,又实现了薄膜芯片和功能电路的单片集成,且芯片尺寸与常规换能元一致。结果表明,集成薄膜芯片尺寸越大,抗静电能力增强;PN 结结构的击穿电压越小,其旁路电流的能力越大,对换能元爆发性性能的影响越大,击穿电压越大,对换能元的静电防护作用越小。本研究芯片集成化程度高且有利于小型化设计, MEMS 工艺便于大规模制备及封装,降低成本并具有较高质量一致性。

攻守兼备

封面背景以平面纵向集成的 PN 结薄膜换能芯片为中心,重点表现了芯片在静电防护电路的独特性能—防静电及电磁干扰。封面正中火焰部分指代芯片在防护工作中换能过程的瞬间,爆炸粒子向四周飞溅,围绕 PN 结薄膜换能芯片的“宝石”,则是薄膜芯片中起到抗静电、抗电磁脉冲防护的独特设计。封面整体上完美体现了芯片在正常爆发的情况下,具有优良的安全性能和高集成化的特点。

封面效果 / @山鹰·翼筒设计

责任编辑 / 姜梅 王馨逸 高毅

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◎ Design and Application of New Energy Exchange Devices

Energetic Express

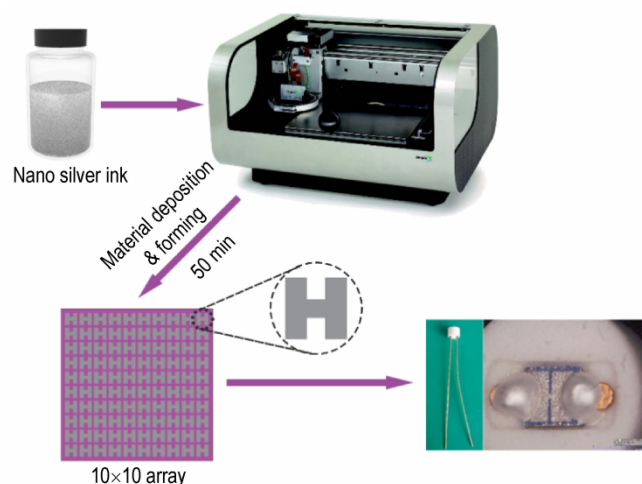
P213★

Pyrotechnics

Preparation and Properties of Inkjet Printing Silver Film Bridge

YI Zhen-xin, LI Lin, WEI Meng-yan, ZHU Shun-guan, LI Yan, ZHANG Lin

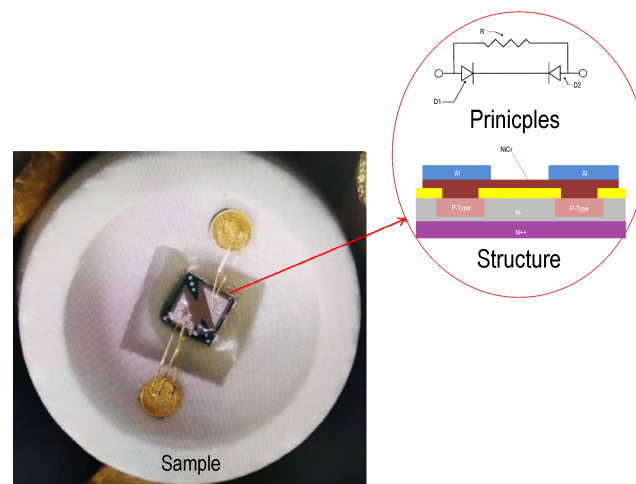
P215★ Based on nano-silver ink, a silver-based energy conversion component (bridge) was prepared using DMP-2850 inkjet printer. The deposition and shape control of the bridge material were completed in one step, which greatly improved the material utilization rate. At the same time, the inkjet printing technology does not need high temperature and low air pressure, and the selection range of substrate materials is wide, which is suitable for mass production. It is a high-efficiency, high-precision, low-cost thin film energy conversion component deposition technology.



Thin Film Transducer Chip with an Integrated PN Junction Protective Structure

LI Hui, LUO Jian-jun, REN Wei, FENG Chunyang, CHU En-yi, CHEN Jian-hua, LI Jiao

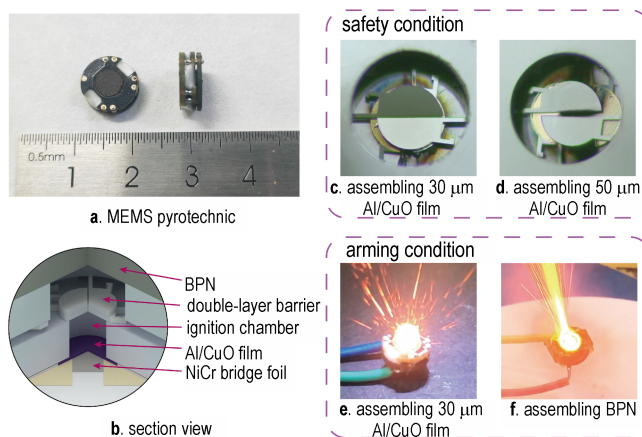
P222★ A thin film transducer chip is proposed with an integrated electrostatic protection circuit. The integrated design and manufacture of thin film energy exchange elements and functional circuits were mainly carried out for initiating explosive devices based upon microelectronics technology. The integrated chip can lead to an improvement in anti-static and anti-electromagnetic pulse capabilities of the thin film chip, and thus to both its monolithic integration with functional circuit and an upgraded safety of initiating explosive device.



Design of a MEMS Ignition Device with a Double-layer Barrier Electro-thermal Safety and Arming Device

WANG Ke-xin, HU Teng-jiang, ZHAO Yu-long, REN Wei

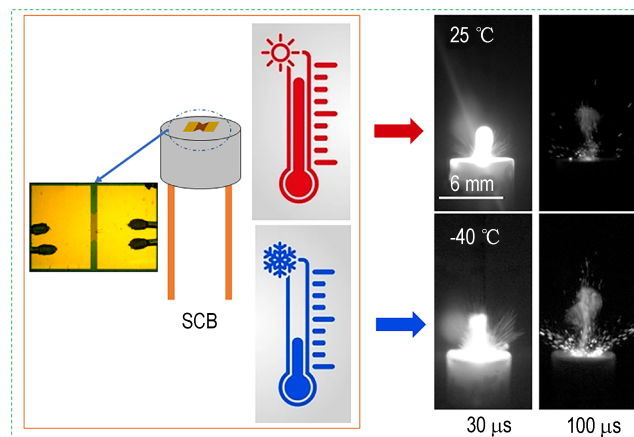
P229★ A MEMS ignition device with a double-layer barrier electro-thermal safety and arming device were designed in this paper. The device had three core components including an igniter, a safety and arming device, and an ignition powder, all of which were assembled linearly with an overall size of $\Phi 10 \text{ mm} \times 3.3 \text{ mm}$. And the safety and arming function test were carried out by controlling the charge quantity of Al/CuO film.



Effects of Temperature on the Electrical Explosion of SCB

WANG Cheng-ai, XU Jian-bing, SHEN Yun, WANG Yue-ting, SHEN Rui-qi, YE Ying-hua

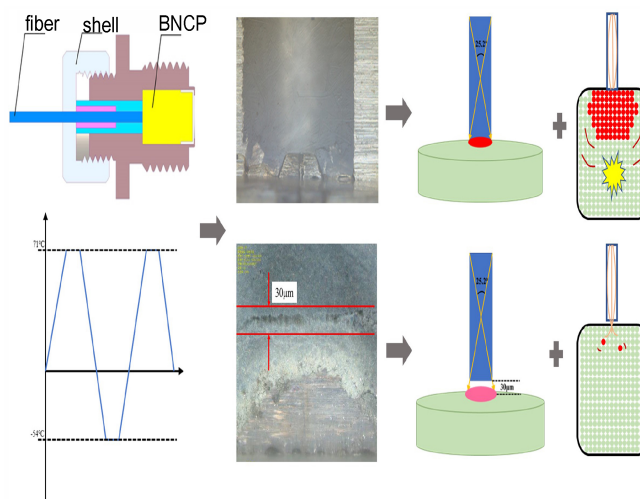
P235 In order to explore the effect of ambient temperature on the electrical explosion of SCB, the electrical explosion characteristics of SCB at room temperature and low temperature by capacitive discharge were tested. And, the effect of low temperature on the electrical explosion of SCB was researched theoretically. Firstly, the electrical explosion and ignition performance of SCB at low ambient temperature and normal ambient temperature were researched. Then, the influence of resistance on the critical initiation time of SCB is analyzed. Finally, the influence of ambient temperature on SCB ignition temperature was analyzed combined with experiment and theory.



Failure Causes and Restraining Method of Fiber Contact Laser Ignited Initiators in Temperature Alternation

XIAN Ming-chun, TONG Le-le, JIAO Jin-fu, XIE Jun-yao, ZHANG Yue-ping, MENG Yan-gang, CHEN Yong, ZHOU Bin, SHEN Rui-qi

P243 ★ In order to explore the influence of temperature impact and cycling on ignition time of laser pyrotechnics, laser initiators with doped BNCP primary explosive carried out an alternating temperature experiment. Moreover, the effect of gap between fiber and explosive was researched theoretically. Firstly, ignition times of laser ignitors with different alternating temperature were studied. Then, the influence of alternating temperature experiment on doped BNCP was analyzed. Finally, the change of laser ignitors structure after alternating temperature experiment was researched.

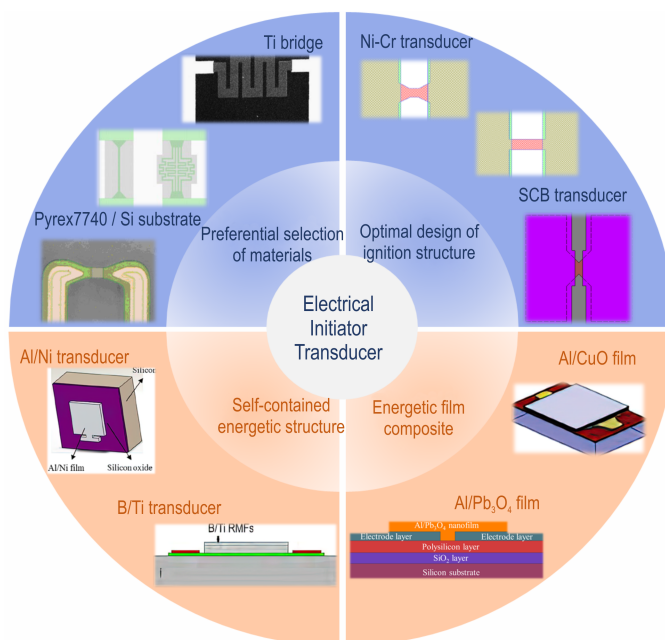


Reviews

Research Progress on Efficiency Improvement of Electrical Initiator Transducers

GU Bo-nan, XU Jian-yong, SHI Wei, SONG Chang-kun, YU Chun-pei, CHENG He, YE Jia-hai, REN Wei, ZHANG Wen-chao

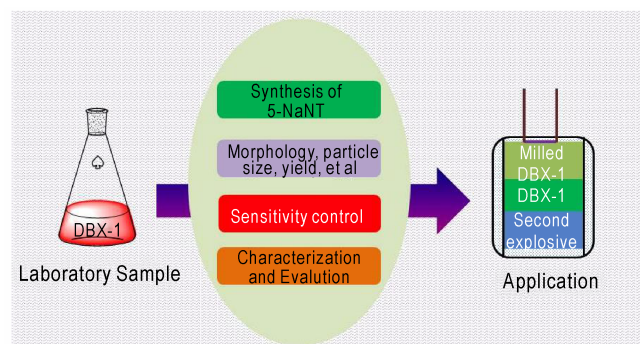
P251 ★ Herein, measures for decreasing the ignition energy and improving the output performance have been summarized for upgrading the efficiency of energy utilization and conversion in electrical initiator transducers. Preferential selection of substrate and resistance materials and optimal design of ignition structure contribute to the low-energy ignition of transducers. On the other hand, self-contained energetic structure and energetic film composite were fabricated for enhancing the output efficiency. Further efficiency researches by means of gene pool of material parameters and machine learning algorithms were also discussed in this review.



Research Progress on Green Primary Explosive Copper(I) 5-Nitrotetrazolate (DBX-1)

NI De-bin, HOU Jian, REN Wei, JIA Yu-xin, ZHANG Meng-yao, CHEN Li, YU Guo-qiang

P266 ★ The research progress of copper(I) 5-nitrotetrazolate and the major raw material sodium 5-nitrotetrazole were reviewed. The synthesis methods and detonation performances, as well as the roadblocks of DBX-1 application were discussed.

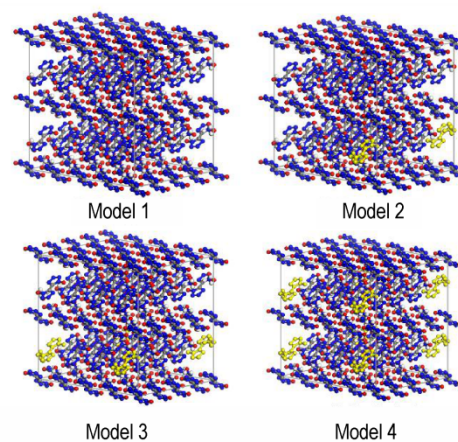


Calculation and Simulation

Molecular Dynamics Simulation on the Effects of Vacancy Defects on the Sensitivity, Mechanical Properties and Detonation Performance of TKX-50

GUO Zhi-wei, HAO Ga-zi, HU Yu-bing, FENG Xiao-jun, YANG Jun-qing, JIANG Wei

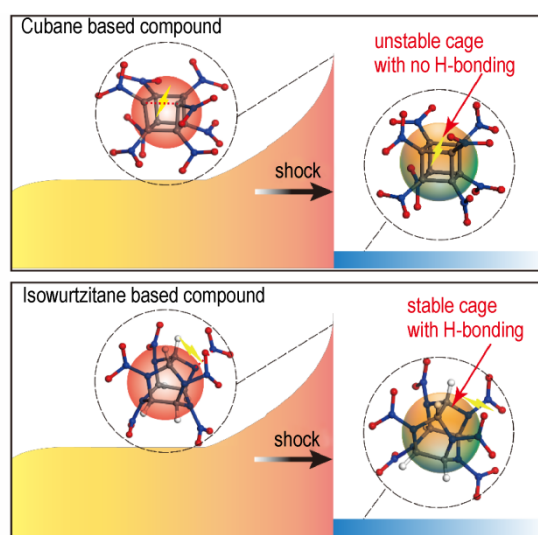
P277 A perfect crystal model (Model 1 with defect concentration of 0%) and a series of vacancy defect models (Models 2-4 with defect concentration of 1.56%, 6.25% and 12.5%, respectively) of TKX-50 were established, and the effects of vacancy defects on the sensitivity, mechanical properties, and detonation properties of TKX-50 were researched. The cohesion energy density, hydrogen bond number, radial distribution function, mechanical properties, and detonation parameters of different models were got and compared.



Reaction Initiation Mechanism of Caged Energetic Crystals under Shock Compression from *ab initio* Molecular Dynamics

SONG Qing-guan, ZHANG Lei, MO Ze-yao

P286 Systematic *ab initio* molecular dynamics calculations were conducted to simulate the early decay of typical caged energetic compounds, and the theoretical results were validated by comparing them with the experimental shock/impact sensitivity tests. The shock initiation mechanism was first revealed from three levels of the structural stability of the caged backbone, the decomposition mode of single molecules, and the collective response of the crystals.

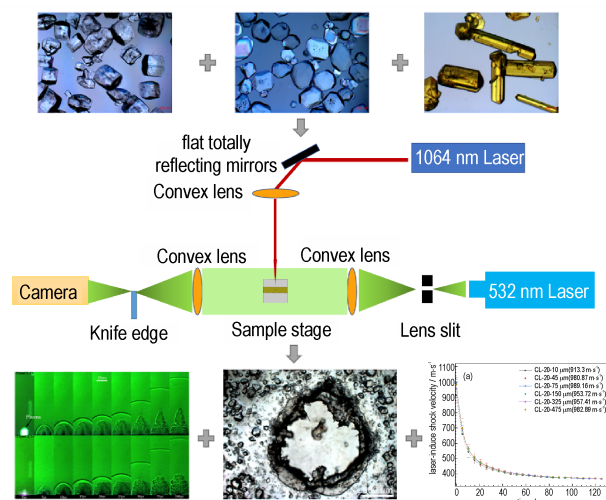


Explosion and Damage

Effects of Particle Properties of Energetic Materials on Laser-induced Micro-explosive Shock Waves

BAO Yuan, GUO Wei, LI Ming, XUE Peng-yi, WANG Xiang, HAO Shi-long, CHEN Si-tong, CAO Wei, XU Jin-jiang, LI Hong-zhen

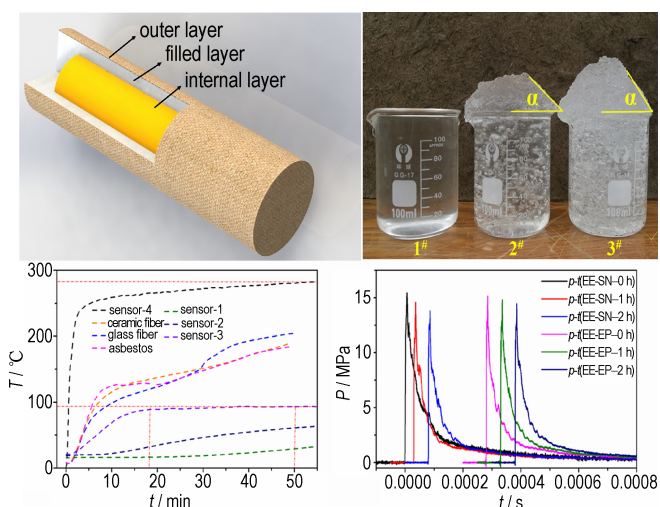
P295 The Laser-induced Air Shock from Energetic Materials (LASEM) method on the milligram scale was conducted on energetic materials with different particle sizes and stacking densities, and the ripple images of laser-induced plasma were captured by a high-speed color scanning camera at the microsecond scale. Comparative observation of the evolution of laser-induced plasma and shock waves in the ripple shadow map of different energetic materials, and the laser-induced shock wave velocities of each group of samples were compared with detonation velocity and pressure peak of shock wave to analyze effects of various influencing factors on the experimental follow-up, in order for LASEM to measure the standard development of detonation parameters.



Thermal Protection and Explosive Performance of Charge Structure with Thermally Insulating Colloid

WANG Fei, MA Hong-hao, SHEN Zhao-wu

P306 In view of the unsafety of the traditional charging method in high-temperature blasting of coal mines, the hierarchical design of the thermally insulating charge structure was completed by adding a colloid layer to the traditional protection structure. The filling samples were selected from three colloidal material formulations. Physical property measurement, thermometric analysis, explosion testing technology and field experiment were carried out.



Executive editor: JIANG Mei WANG Xin-yi GAO Yi