

Editorial

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It has been 70 years since Professor Abdus Salam wrote his first scientific article titled “A Problem of Ramanujan” at the age of 17.¹ I had the privilege of being associated with the International Center for Theoretical Physics (ICTP), now the Abdus Salam International Centre for Theoretical Physics, at Trieste, Italy, from 1982 to 1985. “Founded in 1964 by the late Nobel Laureate Abdus Salam, ICTP seeks to accomplish its mandate by providing scientists from developing countries with the continuing education and skills that they need to enjoy long and productive careers. ICTP has been a major force in stemming the scientific brain drain from the developing world”.² “A prize for young mathematicians from developing countries has been created in the name of Ramanujan by ICTP, in cooperation with the International Mathematical Union, which nominate members of the prize committee.”³ ICTP has been a Mecca for graduate students, postdoctoral fellows, faculty and researchers in all aspects of physics.

This year marks the 40th anniversary since the publication of “Bonds and Bands in Semiconductors” by James C. Phillips.^{4,5} Phillips and his research group^{6–8} proposed new insight into covalent bonding in crystals that followed from studies of energy-band spectroscopy and revolutionized the understanding of macroscopic and microscopic properties of semiconductors. Since then, concepts based on this theory have been utilized to interpret the correlations between physics and chemistry of a variety of elemental and compound semiconductors including binary, ternary and quaternary materials.^{9–11} “Semiconductor Opto-Electronics,” by T. S. Moss, G. J. Burrell and B. Ellis, was also published in 1973.¹² The authors presented an excellent overview of the fundamental properties of semiconductors and their relationship to device properties and performance. Moss proposed relationships between fundamental optical properties such as the refractive index and electronic properties such as the energy gap in semiconductors.¹³ These relationships have been extremely helpful to interpret the opto-electronic properties of semiconductors.

The first article¹⁴ of this issue of *Emerging Materials Research* focuses on “Broadband Unidirectional Ultrasound Propagation Using Sonic Crystal and Nonlinear Medium.” This article, by Dipen Sinha and Cristian Pantea from Los Alamos National laboratory, presents a study on the development of a passive, sonic crystal-based device with unusual properties. This device combines a 1D sonic crystal, a nonlinear medium and an acoustic low-pass filter to allow unidirectional broadband ultrasound propagation as a collimated beam for specialized underwater communication. The

signal (220–400 kHz) to be transmitted is first amplitude modulated with a high-frequency ultrasonic carrier wave (2.7–3.25 MHz) and applied to one side of the device. The device then demodulates this signal and, consequently, the original low-frequency signal appears as a collimated beam on the other side. The sonic crystal provides a bandpass acoustic filter through which the high-frequency ultrasonic signal can pass through and the nonlinear medium then demodulates the signal and also generates the low-frequency sound beam through the parametric array concept. The low-pass filter strips off any remaining high-frequency components and also contributes to the unidirectional property of the device. Design details of the device and experimental data are presented in this study.

A ‘sonic crystal’ is an artificial crystal of a finite-size periodic array composed of sonic scatterers embedded in a homogeneous host material.¹⁵ It must have complete band gaps, where any sound wave is not allowed to propagate into the crystal but is reflected completely by the crystal. A sonic crystal is a sonic version of a photonic crystal.¹⁶

Zeolitic imidazolate frameworks (ZIFs)¹⁷ represent a class of metal organic frameworks that are topologically isomorphic with zeolites. ZIFs are composed of tetrahedrally coordinated transition metal ions (e.g. Fe, Co, Cu, Zn) connected by organic imidazole linkers. Since the metal-imidazole-metal angle is similar to the 145° Si-O-Si angle in zeolites, ZIFs take on zeolite-like topologies.¹⁸ As of 2010, 105 ZIF topologies have been reported in the literature.¹⁹

The second article in this issue,²⁰ “Expanding Catalytic Applications of Pt-Functionalized Metal Organic Frameworks (Pt/ZIF-8): Effects of Calcination Temperatures and Metal Loadings,” is by Zhong He, Guangyu Zhang, Zhiyi Wu, Zheng Qian and Xianqin Wang, of the Department of Chemical, Biological and Pharmaceutical Engineering at the New Jersey Institute of Technology. The authors report their studies on ZIF-8, with and without Pt loadings (0.4 and 2.1 wt.%), prepared at different calcination temperatures (300 and 400°C). The characterization from Brunauer-Emmett-Teller surface measurement and powder X-ray diffraction (XRD) reveals that calcination temperatures and Pt loadings have a significant effect on the porosity and crystallinity of ZIF-8-based materials. ZIF-8 calcined at 300°C (ZIF8-300) has a surface area of more than 800 m²/g with excellent crystallinity, while ZIF-8 calcined at 400°C (ZIF8-400) only has a surface area of less than 100 m²/g with nearly amorphous structure; Pt loading reduces the surface

area by blocking the micropores and lowers the overall Bragg peaks intensity by the inclusion of guest $\text{Pt}(\text{NH}_3)_4(\text{NO}_3)_2$ molecules and/or the formation of Pt nanoparticles in the framework. The surface area and crystallinity decrease with the increase in Pt loadings. 2.1 wt.% Pt/ZIF-8-300 has a surface area of 355 m^2/g and thermal stability up to 500°C; this catalyst shows potential activities for partial oxidation of methanol, because Pt nanoparticles (10 nm) are highly and uniformly distributed in ZIF-8 framework.

“Study on Electrochemical Performance of Carbon-Coated LiFePO_4 ”²¹ by Aide Wu of Flexible Electronic Devices and Sensors Laboratory, New Jersey Institute of Technology and Yuan Gu of Department of R&D Centre for Vehicle Battery and Energy Storage, General Institute for Nonferrous Metals, People’s Republic of China, discusses the synthesis of LiFePO_4/C materials by carbon thermal reduction method and the characterization of obtained composites. XRD patterns show that the synthesized product is LiFePO_4 phase without the existence of any impurities. Scanning electron microscopic images show the synthesized LiFePO_4 particles to be nano sized, and carbon forms a conductive network between LiFePO_4 particles. Transmission electron microscopy results indicate that carbon is successfully coated on the surface of LiFePO_4 particles. Raman spectroscopy shows the coated carbon to have low degree of graphitization. Compared with pure LiFePO_4 samples, LiFePO_4/C materials exhibit higher electronic conductivity and better electrochemical properties especially at high rate charge/discharge conditions.

Pashinska, Varyukhin, Dobatkin and Zavdoveev of Donetsk Institute for Physics and Engineering NAS of Ukraine, report their studies²² on the “Mechanisms of Structure Formation in Low-Carbon Steel Deformed by Warm Twist Extrusion ($T_{\text{def}} = 400^\circ\text{C}$).” The analysis of electron backscattering diffraction shows that dynamic recrystallization and grain boundary sliding play an active role in structure formation in the process of severe plastic deformation. It has been shown that severe plastic deformations induce dissolution of carbon.

The “Strength Evaluation of Clinker Stabilized Fly ash–mine–overburden Composites as an Alternative Haul Road Construction Material”²³ is a study by Soumya Ranjan Mallick and Manoj Kumar Mishra of the Department of Mining Engineering, National Institute of Technology, Rourkela, India. In this investigation, the authors discuss opencast coal mining and its role in meeting the demand for fossil fuel. Large capacity haul trucks are being increasingly used to meet this demand. These trucks need well-designed haul roads. Opencast mining also imposes adverse conditions on the area due to substantial overburden lying unreclaimed. The current fly ash production is about 180 MT that will rise to about 600 MT by 2030 in India. It adversely affects land, air and water resources. Strong effort is required to address this issue. An investigation has been taken up to evaluate the use of both fly ash as well as mine–overburden material along with

a selected additive to develop an alternative construction material to be used in the sub-base of haul road. This article reports the detailed laboratory investigations carried out on the development of fly ash–composite material with mine–overburden and clinker and determination of their suitability for haul road. Proctor compaction test, unconfined compressive strength test, Brazilian tensile strength test and scanning electron microscopy were carried out. The composite with 62% fly ash, 30% overburden and 8% clinker exhibited adequate strength value for the haul road construction.

In a collaborative effort between National Institute of Technology, Rourkela, India and Dalmia Institute of Scientific and Industrial Research at Rajgangpur, India, Tiwary, Sarkar, Mishra and Mohanty report their studies²⁴ on the “Structural Aspects of Blast Furnace Slag.” Interdependence of structure and viscosity of blast furnace slag is discussed based on the available literature. Emphasis is given to both, bridging tendency and network breaking/modifying tendency of the constituents. It is clearly pointed out that slag viscosity cannot be explained only by a process of depolymerization through an increase of basicity despite the fact that an increase in basicity of the slag, in general, lowers the viscosity of the slag by a process of generation of discrete anions containing simple chains and/or rings by causing depolymerization of the 3D silicate network.

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