

# Optical Engineering

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## **Optical Materials**

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New optical materials and processes for making novel materials is key to almost all scientific developments of optical systems and devices, including lasers, sensors, detectors, cameras, solar cells, and communication and space systems. For example, optical communication, which is the basis for internet, phone, and data systems, started with the advent of low-loss optical fibers in the early 1970s. Low-loss fibers became a reality because of the invention of a new vapor phase deposition process which enabled the manufacture of ultimate high-purity glass materials. The solar cell devices for much-needed energy harvesting also depend on new materials. Therefore, research in new materials, processes, characterization, and diagnostic techniques are always very important and essential.

The first paper in this special section by Medina and Díaz is on characterization of reflectance variability in the industrial paint application of automotive metallic coatings. They have applied principal component analysis to examine trial-to-trial variability of reflectances of automotive coatings that contain effect pigments. Reflectance databases were measured from different color batch productions using a multiangle spectrophotometer. A method to classify the principal components was used based on the eigenvalue spectra. It was found that the eigenvalue spectra follow distinct power laws and depend on the detection angle. Their findings indicate that principal component analysis can be a useful tool to classify different sources of spectral variability in color engineering.

In another paper, Chobola et al. describe the low-frequency noise, microplasma, and electroluminescence measurements as a faster tool to investigate the quality of monocrystalline-silicon solar cells. They produced two sets of c-Si solar cells varying in front side phosphorus-doped emitters by standard screen printing techniques. This paper presents a comparison of solar cell conversion efficiency and results from a noise spectroscopy, microplasma, and electroluminescence presence. Noise spectral density reflects the quality of solar cells, and thus it represents an alternative advanced cell diagnostic tool.

The paper by Canestrari et al. is on cold-shaping of thin glass foils as a novel method for processing of mirrors. It shows a basic concept, employing commercial off-the-shelf materials, that could be converted into mass production of mirrors. It is based on the shaping of thin glass foils by means of forced bending at room temperature (cold-shaping). The principal mechanical features of the mirrors are the very low weight, rigidity, and environmental robustness; they are also low in cost.

La Spada, Iovine, and Vegni present electromagnetic modeling of ellipsoidal nanoparticles for sensing applications. In this paper, a new analytical study of metallic nanoparticles

working in the infrared and visible frequency range is described. The structure consists of triaxial ellipsoidal resonating inclusions embedded in a dielectric environment. The aim of this study is to develop a new analytical model for the ellipsoidal nanoparticles in order to describe their resonant behavior and design structures that satisfy specific electromagnetic requirements. The obtained models are compared to the numerical values performed by full-wave simulations, and to the experimental ones reported in literature. A good agreement among these results was obtained. The proposed formula is a useful tool for designing structures for sensing applications.

The final paper by Rispoli et al. on the ELENA microchannel plate detector claims to have absolute detection efficiency for low-energy neutral atoms. Microchannel plate (MCP) detectors are frequently used in space instrumentation for detecting a wide range of radiation and particles. The capability to detect nonthermal low-energy neutral species is crucial for the Emitted Low-Energy Neutral Atoms (ELENA) sensor. ELENA is a time-of-flight sensor, based on a concept using an ultrasonic oscillating shutter and MCP detector. The ELENA scientific objective is to monitor the emission of neutral atoms from the surface of Mercury. MCP absolute detection efficiency for very low-energy neutral atoms ( $E < 30$  eV) is a crucial point for this investigation. They performed measurements on three MCPs with different coatings to provide the first data of MCP detection efficiencies in the energy range 10 eV–1 keV.

These papers cover a very broad spectrum of technology from paints to solar cell and space innovations. Optical materials research covers a very broad area and is very important for all optical systems for every kind of application.



**Ishwar D. Aggarwal** is currently a research professor in physics and optical science at the University of North Carolina at Charlotte. He is responsible for planning and directing research activities in infrared materials and devices, and imprinting of micro and nanostructures in infrared optical materials for antireflection and wavelength filter applications. Previously, he was head of the Infrared Materials and Devices Branch in the Optical Sciences Division at the Naval Research Laboratory (NRL). Before joining NRL, he was a vice president responsible for engineering at Lasertron, Inc., where he directed engineering work on semiconductor lasers, detectors, transmitters, and receivers for communications applications. He previously worked at Corning, Inc. and Valtec Corporation (a Philips subsidiary). He has published over 250 papers in various technical journals, edited two books on *Fluoride Glass Fiber Optics* and *Infrared Fiber Optics*, and holds more than 75 issued patents and an additional 40+ patent applications. He received his PhD in materials science from Catholic University of America and B.Tech. from Indian Institute of Technology, Bombay, India.