EDITORIAL

MATERIALS & ENGINEERING: Propelling Innovation

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Materials and engineering are soulmates. Materials transform designs and equations into artifacts. Engineering, in turn, enables this transformation. Advancements in one have propelled advances in the other, creating new and well-integrated technologies. The relationship between materials and applications remained empirical throughout most of history, with clever artisans shaping materials that were obtained in native form in land and riverbeds. This experience was well recognized in ancient texts, such as in the Indian King Somadeva III writings in *Manasollasa* and by the Tamil Saint Ilango in the Tamil epic *Silapadhiharam*. There are similar examples from ancient Greece and Italy. Such references, however, are few and far between. In the ancient world, materials and design were yet to become commonplace, except in the form of fired clay pots and pans and other implements.

Technological revolutions in the 18th and 19th centuries made new pathways possible in this intertwining of materials and engineering. The Industrial Revolution was propelled by the development of coal mining and the Bessemer process for iron and steel making. For the first time, iron and steel could be produced on a scale of thousands of tons. This availability of steel and other alloys in large quantities boosted engineering applications, giving rise to steam power, machine tools, and industries with output on a massive scale.

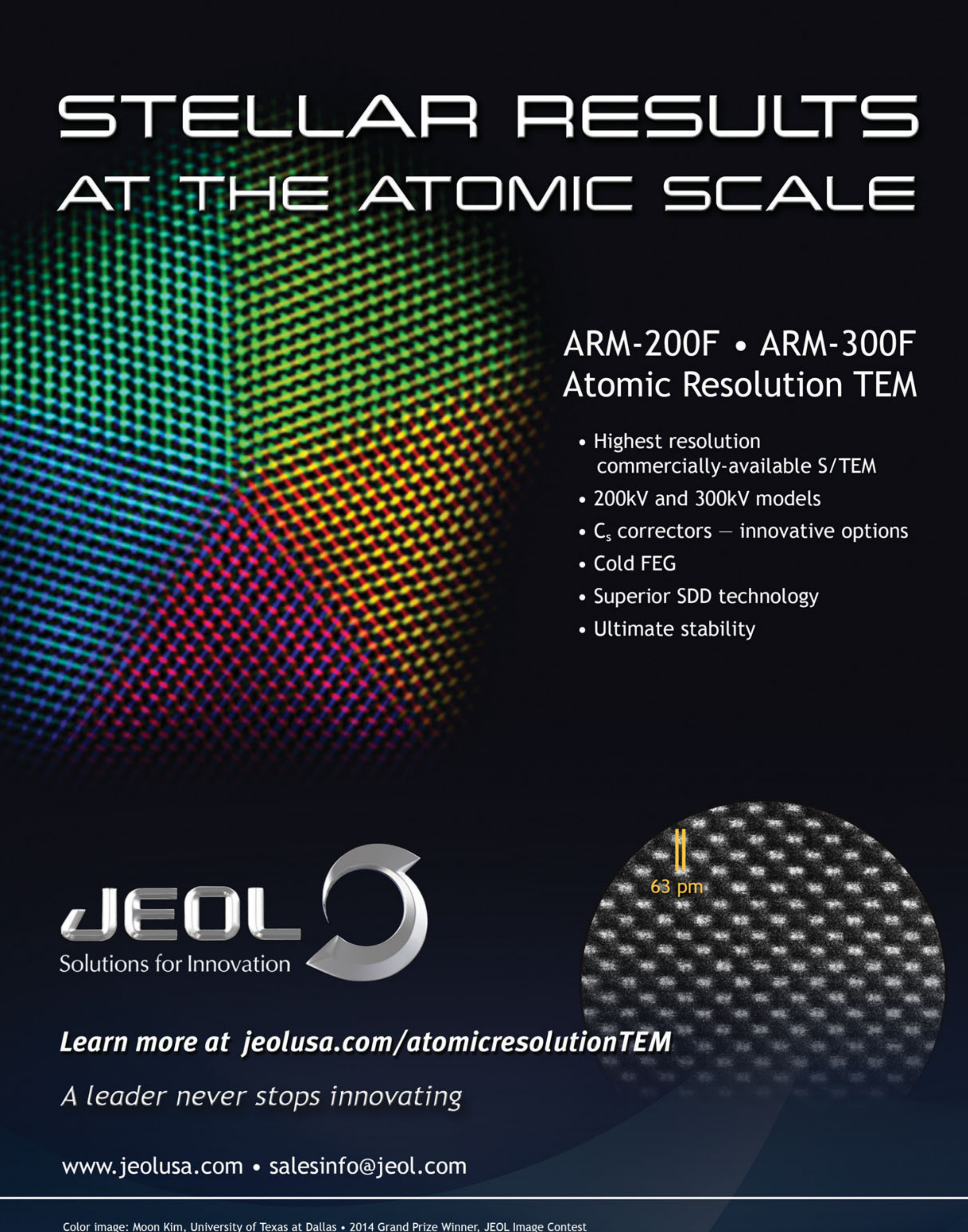
Past the Industrial Revolution and into the 20th century, demands for new materials with newer applications increased steeply, such as for automotive and aerospace applications. This necessitated better understanding of the behavior of these materials and a move away from empiricism. Newtonian mechanics and thermodynamics that established the relationships among temperature, energy, and entropy of physical bodies provided the initial tools to develop new materials. In a sense, this formal knowledge created a bridge between the two entities of materials and engineering, where engineering described the demand and designs, and materials provided the artifacts with tailored properties.

The connection between materials and engineering is not static. With experience, many empirical relationships that were compatible with formal knowledge were developed. Formal knowledge, in turn, became more sophisticated, thanks to accurate measurements and predictions of properties, development of relevant theoretical underpinnings, and the availability of computing power for simulations and modeling. Today, the association between materials and engineering extends to the quantum domain, and even further to the molecular and atomic scale. For instance, band theory on a fundamental level explains the distinction between metals, semiconductors, and insulators. This knowledge paved the way for the synthesis of numerous semiconductor compositions used in real devices.

In the development cycle, innovations with new materials and relevant engineering do not emerge at the same time. Glass fiber, as a case in point, was in need of an application until optical fiber technology for communication became crucial. Optical fiber-based communication has now replaced cumbersome electronics amplifiers. This "out-of-phase" between new materials and engineering is also seen in the present-day development of nanoscale materials, where, in many cases, engineering processes to manufacture nanoscale materials in useful quantities are still not available.

This special issue of *MRS Bulletin* focuses on the unique interplay between materials and engineering, which drives and motivates materials innovations and a large proportion of materials science research explicitly and implicitly. The goal of the articles in the issue is to describe the road traversed in establishing the relationship between materials and engineering, and to present a spectrum of new materials with enticing properties and relevant engineering applications. The relationship between materials and engineering remains fertile and ongoing, as evidenced by the plethora of new materials available today, such as biomaterials and materials for energy. Newer technologies such as 3D printing and quantum computers further push materials boundaries.

The articles in this issue suggest that the intertwining between materials and engineering continues to surprise—from scientific, technological, and economic viewpoints. Through the prism of materials science, the future looks brighter than ever with the promise of new artifacts through new materials, processes, and designs for the betterment of human society.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