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Imperfections: the perfect materials platform

Some people seek perfection. UC Santa Barbara materials professor **Daniel Gianola** is focused on creating, finding and exploring imperfections, with an eye to developing new and better materials.

“Our work is all about the imperfections — defects — because they control a material’s properties, so we want to be able to see them and their dynamics, and that’s what we do in the microscope,” Gianola said.

He recently received three prestigious awards for this research.

With the 2026 Brimacombe Medal from The Minerals, Metals & Materials Society (TMS), bestowed upon outstanding members of the materials community, Gianola was recognized for “innovation in *in situ* electron microscopy and the micromechanics of crystal defects, as well as for his dedicated service to TMS programming.”

Those accolades are echoed in the announcements of the other two awards, both from institutions in Germany: the 2026 Alexander von Humboldt Fraunhofer-Bessel Research Award and the 2026 Karlsruhe Institute of Technology (KIT) International Excellence Fellow.

Conferred annually to “internationally known researchers from any discipline in recognition of their entire academic record to date,” the Bessel Award also came with an invitation for Gianola to “carry out research projects of his own choice in cooperation with specialist colleagues in Germany.”

Gianola this month will begin a sabbatical at KIT, where he will have “access to the scientific, administrative and social infrastructure of KIT and enjoy comprehensive personal support.”

“I’m profoundly honored by these awards, which, I like to think, validate years spent with my students, postdocs, and collaborators joyfully trying to understand the tiniest features in materials that stubbornly refuse to behave,” Gianola said.

“Realizing the countless materials-based technologies that have been developed at UCSB and elsewhere requires a deep understanding of the structure of a material and how it informs its unique characteristics and capacities — a continuous learning process,” said **Umesh Mishra,** dean of The Robert Mehrabian College of Engineering. “Dan Gianola’s lab has helped not only to expand the capacity of existing characterization tools — especially in the realm of electron microscopy — but also the development of new ones used in such research. He richly deserves these honors, and we at the COE offer him both our sincere congratulations and our gratitude for his key role in making possible so many advances in materials science and engineering.”

Gianola has for years focused his research on characterizing materials across many length scales, including down to the atomic level, especially materials applied in extreme environments, such as components for jet engines and lightweight transportation.

The phrase “materials that stubbornly refuse to behave,” Gianola said, “is a general statement, but it gets at the core tenet of materials science, which is to elucidate the relationships among structure and property, which, in turn allows materials scientists to design and synthesize new materials to meet the demands of next-generation technologies.”

To that end, Gianola has been working with materials colleague Professor Tresa Pollock to adapt the latest electron-camera technology, incorporating what is called a *direct electron detector* — to a scanning electron microscope (SEM). Until recently, the camera had been used only in very expensive transmission electron microscopes (TEMs) but never in the less-expensive SEMs.

With an idea to try to get the best camera into the SEM platform, Gianola started making calls. A company called Direct Electron, based in San Diego, was game. “We’ve been pursuing really interesting work with them in the six or so years since,” Gianola said.

The cameras were made possible by the development of a radiation-hard sensor, he explained, which eliminated the need to first convert electrons to visible light through a phosphorescent screen, the standard commercially available solution to date. “This new generation of camera makes it possible to detect and count every electron that hits the detector, thus providing super-high sensitivity and the ability to go really fast and get all the characteristics of what’s happening,” he said. “Very few people thought to tune things to the energies of the SEM platform, but with the new detectors, an SEM can produce results with information that would normally require a TEM.”

Direct Electron, which makes the cameras, is now commercializing the detector, which had to be redesigned for an SEM. “It has been super-fun to see it go from just a crazy idea to a prototype and, now, to one that looks more like a packaged product,” noted Gianola.

Seeking, inserting and wanting the imperfections in a material is an age-old interest of materials scientists and engineers. Treating the defects and their chemical and structural microenvironment as objects to design, however, represents a relatively new paradigm in materials science.

“Only in the past ten years or so have people begun talking about *defect phases,”* Gianola said, “and now they are a big part of what we're after, treating defects as the basis for creating new materials or characteristics we wouldn't get otherwise in the bulk material. It's the imperfections that are so important, and, just as in humans, they're what make the materials interesting.”

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