Faculty members' semiconducting work draws attention from NASA

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The ceramic compound yttrium-barium-copper-oxide has been under close observation for the past 10 years because of its superconductive ability.

According to Lawrence Berkley Laboratories, the new YBCO thin-film-based tapes are expected to succeed in high-performance applications that require access to higher current densities, higher magnetic fields or higher temperatures than any other process.

Recently, however, associate professors of electrical engineering Donald Butler and Zeynep Celik-Butler have been focusing on the semiconducting abilities of the compound. The result of their research is a new generation of infrared detectors, sponsored by both NASA and the Army Research Office.

"We have been able to get near room-temperature-fluctuation with limited noise," Butler said, "and that means good responsivity."

Infrared images display gradients of temperature differences. Infrared sensors pick up data both day and night. They show the pattern of heat (infrared radiation) released from the Earth. Heat-producing areas, such as warm water currents or cities (with heat-absorbing concrete and asphalt and heat-producing cars, people, and factories) are bright spots on infrared images. Clouds appear in varying shades of grey, depending on their temperature, which is determined by their height above Earth.

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> **Zeynep Celik-Butler,**
> associate electrical engineering professor

"We expect to explore needed advances in detector technology that will allow for a new generation of instruments to measure the radiation in relatively narrow spectral bands that partition the atmospheric and surface energy budget in ways that are not possible with the classic broadband scanners used previously," Celik-Butler said.

Butler and Celik-Butler have developed "semiconducting microbolometer" out of yttrium-barium-copper-oxide to replace current materials used in infrared imaging. Because of its unique qualities, the yttrium compound offers a higher temperature coefficient than materials that are currently being used. In addition, it offers more resistance, which results in a larger signal with the same amount of light conventional materials receive.

"When compared to common materials for pyroelectric detection such as lead titanate, barium strontium titanate, this is about 200 times higher," Celik-Butler said.

The new detectors are fast, lightweight, and cost under $1,000. This can be compared with currently used infrared imaging devices, which can be priced at more that $10,000. The detectors have been designed for easy integration with silicon signal processing circuitry.

"This technology would enable that kind of development-significant price difference in the end product," Butler said.

Uses for yttrium detectors include medical applications, gas sensors and pollution monitoring. The infrared detectors have also caught the attention of scientists at the NASA Langley Research Center in Hampton, Va. Thermal processors would be useful in determining the effects of cloud coverage on global warming. Current broadband scanners cannot detect narrow radiation fluxes, and are less mobile and responsive than the new material.

"We believe that the material is easy to fabricate in a manufacturing environment, is compatible with micromachining and does not require any high-temperature processing," Celik-Butler said. "In fact, it may be easier than most current materials because it does not require any high-temperature processing."

Butler and Celik-Butler have previously worked together examining the use of yttrium-barium-copper-oxide in superconducting microwave devices. In 1987, Celik-Butler received a $100,965 grant from the National Science Foundation for her research into "Low-frequency Noise Measurements as a Characterization and Testing Tool in Solid-State Devices."